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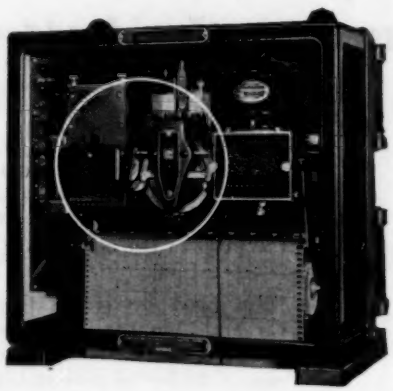

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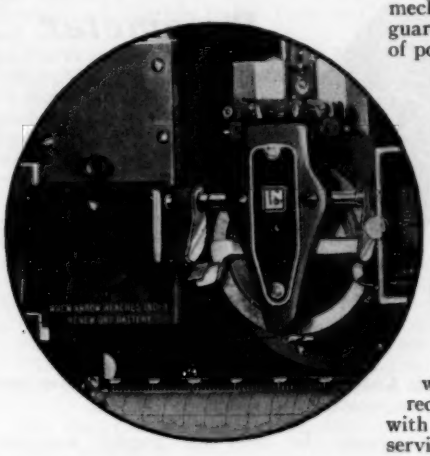

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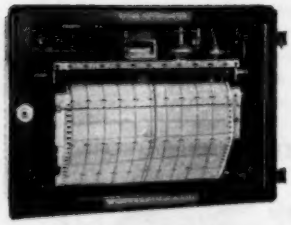

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THE EFFECT OF FIRING TEMPERATURE ON THE DIELECTRIC STRENGTH OF PORCELAIN[1]

By A. J. Monack and L. R. Shardlow

ABSTRACT

An electrical porcelain body (H and G A1 English china clay, 30%; Tennessee ball clay No. 7, 20%; Buckingham feldspar, 30%; Ottawa flint, 20%) was fired to various cone temperatures and the puncture voltages were determined. The mean values in kilovolts per quarter-inch thickness were cone 7, 37; cone 8, 51; cone 9, 60; cone 10, 63; cone 11, 61; cone 12, 64. The probable error of the mean in each case is approximately ±1 kilovolt per quarter inch. The differences of the means between cones 9 and 12 were shown statistically to be without significance. Other conditions remaining identical, it was shown that the most uniform body resulted when fired to cone 9.

I. Introduction

Little information is to be found concerning the relation between firing temperature and the dielectric strength of porcelain. Data found in the literature are, in most cases, of doubtful accuracy because of the small number of specimens which were tested. This paper presents data from tests in which the number of specimens used was sufficiently large to give mean values with small probable errors.

II. Experimental Details

An electrical porcelain body of the following composition was used in this study:

	(%)
H and G A1 English china clay	30
Tennessee ball clay No. 7	20
Buckingham feldspar	30
Ottawa flint	20

The body was prepared in the usual manner by blunging, filter-pressing, and wedging. The test specimens were formed by hand-pressing in a small brass mold. The dimensions were such that after firing, the test piece was a paralallopiped approximately 2 inches by 2 inches by $^1/_4$ inch. Before firing, the large faces of the dried specimens were carefully rubbed over fine sand-paper in order to obtain two smooth surfaces to which the electrodes

---

[1] The data presented in this paper were obtained in an investigation financed by the Utilities Research Commission, Inc., Chicago, Illinois. The experiments were conducted as part of the work of the Engineering Experiment Station and will be presented in a *Bulletin* of the Engineering Experiment Station, University of Illinois, Urbana, Illinois. The authors wish to acknowledge the aid of J. O. Krachenbuehl, Electrical Engineering Department and of D. H. Wamsley, Ceramic Engineering Department.

Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (White Wares Division). Received July 9, 1931.

could be fastened. After this operation the specimens were fired in a small kiln, one series at a time, with absolutely uniform firing conditions. Figure 1 shows the firing schedule used and this was followed exactly in each case.

TABLE I

EXPERIMENT DATA ON DIELECTRIC STRENGTH

Sample No.	Kilovolts to puncture	Thickness* (inch)	Kilovolts/1/4 inch	Sample No.	Kilovolts to puncture	Thickness* (inch)	Kilovolts/1/4 inch	Sample No.	Kilovolts to puncture	Thickness* (inch)	Kilovolts/1/4 inch
7–1	33.5	0.215	39.0	8–1	42.0	0.227	46.5	9–1	50.0	0.201	62.0
7–2	26.5	.219	30.0	8–2	43.0	.220	49.0	9–2	52.0	.193	67.5
7–3	38.0	.214	44.5	8–3	46.5	.226	51.5	9–3	51.5	.201	64.0
7–4	29.0	.184	39.5	8.4	38.0	.229	41.5	9–4	45.0	.198	57.0
7–6	27.5	.237	28.0	8–5	41.0	.210	49.0	9–5	46.5	.199	58.5
7–8	37.5	.211	44.5	8–6	52.0	.224	58.0	9–6	52.0	.196	66.5
7–9	28.0	.179	39.0	8–7	42.5	.221	48.0	9–7	51.0	.198	64.5
7–10	34.5	.188	46.0	8–8	45.0	.245	46.0	9–8	52.0	.211	61.5
7–11	30.5	.231	33.0	8–9	50.5	.243	52.0	9–9	54.5	.204	67.0
7–12	26.5	.186	35.5	8–10	49.5	.210	59.0	9–10	48.0	.186	64.5
7–13	29.0	.230	31.5	8–11	38.5	.222	43.5	9–11	44.5	.201	55.5
7–14	32.0	.217	37.0	8–12	40.0	.230	43.5	9–12	47.0	.224	52.5
7–15	29.5	.226	32.5	8–13	48.0	.233	51.5	9–13	56.0	.218	64.0
7–16	32.0	.245	32.5	8–14	48.0	.238	50.5	9–14	41.0	.176	58.5
7–17	32.5	.193	42.0	8–15	51.5	.238	54.0	9–15	46.5	.217	53.5
7–18	32.0	.194	41.0	8–16	52.5	.222	59.0	9–16	52.0	.205	63.5
7–19	28.0	.242	29.0	8–17	49.5	.214	58.0	9–17	51.5	.220	58.5
7–20	30.0	.199	38.0	8–18	47.0	.218	54.0	9–18	47.5	.198	60.0
				8–19	42.0	.218	48.0	9–19	55.5	.241	57.5
				8–20	48.5	.220	55.0	9–20	46.0	.210	55.0
10–1	50.0	.198	63.0	11–1	55.5	.217	64.0	12–1	48.0	.211	57.0
10–2	53.5	.216	62.0	11–2	49.0	.201	61.0	12–2	49.0	.214	57.0
10–3	52.0	.202	64.5	11–3	49.0	.239	51.5	12–3	60.5	.217	69.5
10–4	49.0	.213	57.5	11–4	53.0	.219	60.5	12–4	50.0	.200	62.5
10–5	62.0	.226	68.5	11–5	58.0	.224	65.0	12–5	44.0	.184	60.0
10–6	58.0	.184	79.0	11–6	45.0	.224	50.5	12–6	52.0	.212	61.5
10–8	55.0	.214	64.0	11–7	58.5	.206	71.0	12–7	47.0	.208	56.5
10–9	53.0	.232	57.0	11–8	55.0	.198	69.5	12–8	61.0	.209	73.0
10–10	54.5	.258	53.0	11–9	51.0	.221	58.0	12–9	57.5	.195	73.5
10–11	54.0	.211	64.0	11–10	46.5	.206	56.5	12–10	52.0	.214	60.5
10–12	50.0	.206	60.5	11–11	55.0	.225	61.0	12–11	51.5	.213	60.5
10–13	56.0	.220	63.0	11–12	60.0	.226	66.5	12–12	51.0	.206	62.0
10–14	57.0	.207	69.0	11–13	48.5	.219	55.5	12–13	42.5	.208	51.0
10–15	43.0	.184	58.5	11–14	46.5	.222	52.5	12–14	52.0	.216	60.0
10–16	51.0	.203	63.0	11–15	60.0	.217	69.0	12–15	53.0	.224	59.0
10–17	55.0	.220	62.5	11–16	45.5	.219	52.0	12–16	55.0	.186	74.0
10–18	53.0	.231	57.5	11–17	49.0	.211	58.0	12–17	59.0	.202	73.0
10–19	54.0	.215	63.0	11–18	51.5	.214	60.0	12–18	60.5	.227	66.5
10–20	55.5	.215	64.5	11–19	59.0	.222	66.5	12–19	61.0	.220	69.5
				11–20	54.5	.209	65.0	12–20	58.0	.193	75.0

* Mean of 5 measurements near the puncture.

Cones were placed on the four sides of the pile of specimens in the sagger and the samples were rejected if all of the sets of cones did not record the same firing temperature.

The fired specimens were carefully scrubbed with soap and water, washed in distilled water, and rinsed in alcohol. The electrodes were fastened in place as shown in Fig. 2 and the specimens were kept in

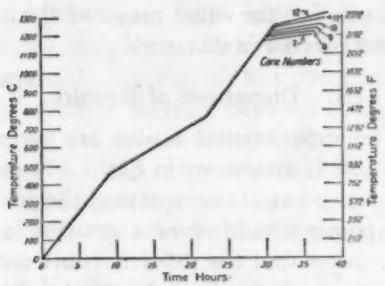

FIG. 1.—Firing schedule used for the specimens.

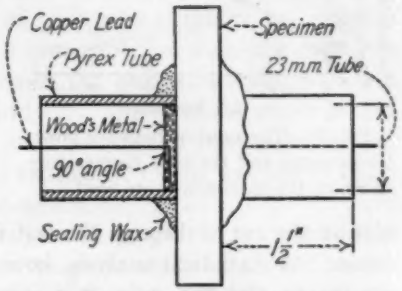

FIG. 2.—Method of fastening the electrodes to the porcelain specimen.

an oven for at least one hour in order to heat them uniformly to 35 to 37°C.

The puncture voltages were determined by placing the specimens in an oil bath which was maintained at a constant temperature of 36°C, and

TABLE II

SUMMARY OF RESULTS OF EXPERIMENTAL DATA

Series	Number of Samples	$\overline{X}$	σ	$p.e$	$P.E.$	C (%)	$P.E.$ %
7	18	37	5.5	3.7	0.92	15	2.5
8	20	51	5.3	3.6	0.84	11	1.6
9	20	60	4.4	3.0	0.69	7	1.2
10	19	63	5.5	3.7	0.89	9	1.4
11	20	61	6.2	4.2	0.98	10	1.6
12	20	64	6.8	4.6	1.1	11	1.7

$\overline{X}$ = arithmetic mean
σ = standard deviation
$p.e.$ = probable error of a single observation = 0.6745σ
$P.E.$ = probable error of the arithmetic mean

$$C = \text{coefficient of variability} = \frac{\sigma}{\overline{X}} \times 100$$

$$\%\, P.E. = \frac{P.E.}{\overline{X}} \times 100$$

(For definitions of the statistical terms used above see Handbook of Mathematical Statistics, H. L. Rietz, Editor-in-Chief, Houghton Mifflin Company, New York, 1924.)

applying the voltage at a constant rate. The voltage increase was registered by a recording voltmeter which ceased to record at the moment of puncture.

After the completion of the puncturing tests, five measurements of the thickness of each specimen near the puncture were made. These measure-

ments were averaged to obtain the mean thickness and all results were calculated to kilovolts per one-quarter inch of thickness. It may be assumed correctly that the relation between puncture voltage and thickness is linear for the small range of thicknesses covered in this work.

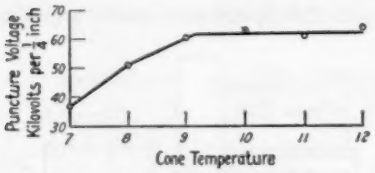

FIG. 3.—The relation between puncture voltage and the cone temperature to which the specimens were fired.

III. Discussion of Results

The experimental results are given in Table II and shown in Fig. 3. From the viewpoint of curve fitting, the portion of the curve through the last four points should show a gradual increase. A statistical analysis, however, shows that the differences are not significant and the curve was accordingly made horizontal. If the differences between the means of the series and the probable errors of the differences are calculated the following table results.

	Difference between means	Probable error of difference	Z = ratio between difference of means and probable error of the difference
Series 10 and 11	2 KV.	1.35	1.48
Series 11 and 12	3	1.49	2.01
Series 10 and 12	1	1.42	0.71
Series 9 and 10	3	1.14	2.60
Series 9 and 12	4	1.30	3.10
Series 8 and 9	9	1.06	8.50

It can be shown[2] that the odds against the occurrence of a ratio greater than Z are as follows:

Z	Odds
1.48	2 to 1
2.01	4.5 to 1
0.71	1 to 1
2.60	11 to 1
3.10	23 to 1
8.50	200,000,000 to 1

Only in the last case are the odds great enough to assume that the difference is significant. The odds for the difference between the means of the cone 7 and the cone 8 series are approximately 1,000,000,000 to 1 and there is no question concerning the significance of the difference.

Since the above calculations failed to show that the differences between the means for the series fired to cones 9, 10, 11, and 12 were significant, that portion of the curve (Fig. 3) between cones 9 and 12 was drawn as a horizontal line. The use of a much larger number of samples (probably 50 in number) with the consequent reduction in the probable errors of the means may show a slight upward trend in the range covered.

The values of the standard deviation (σ), the coefficient of variability

[2] Lovett and Holtzclaw, Statistics. Prentice-Hall, N. Y., 1929, pp. 279–80.

(C), and the probable error of the mean ($P.E.$) give quantitative measurements of the uniformities of the bodies tested since all conditions of preparation and firing and testing remained the same throughout the work. Figures 4 and 5 indicate that the most uniform body was obtained at cone 9, with the non-uniformities increasing on both sides of this point. Higher firing temperatures than cone 9 do not noticeably increase the dielectric strength (see Fig. 3) but the variations in the puncture voltage show a progressive increase between cones 9 and 12. The range in which 99.7% of all the values will fall (3σ) is 1.54 times as large at cone 12 as it is at cone 9. The range in which 95% of all arithmetic means will fall (0.463σ) is 1.54 times as great at cone 12 as it is at cone 9.

From the viewpoint of dielectric strength the proper firing temperature for the porcelain used should be between cones 9 and 10; from the viewpoint of mechanical properties

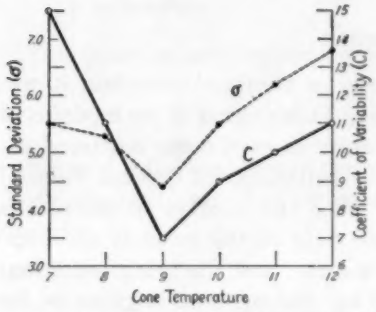

FIG. 4.—The relation between the standard deviation (σ), the coefficient of variability (C), and the cone firing temperatures.

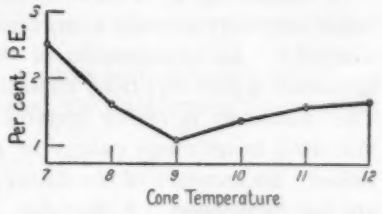

FIG. 5.—The relation between the percentage probable error of the mean (% P.E.) and the cone firing temperature.

(modulus of elasticity, tensile strength, modulus of rupture, etc.), a higher firing temperature may be indicated. In such a case the best firing temperature would be a suitable compromise between the important properties.

IV. Summary

(1) The puncture voltage was found to increase rapidly in the firing temperature range between cones 7 and 9; between cones 9 and 12 the puncture voltage was constant.

(2) The standard deviation, the coefficient of variability, and the probable error of the mean showed minimum values at cone 9 and indicated that the most uniform body was obtained at this firing temperature.

(3) The variations in any property with respect to firing temperatures and the determination of the temperature at which the most uniform body (as shown by the probable error of the mean) results offer a means of showing the temperature to which electrical porcelain (or other ceramic materials) should be fired.

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THE MODULUS OF ELASTICITY AS AN INDICATION OF THE UNIFORMITY OF ELECTRICAL PORCELAIN[1]

By A. J. Monack

ABSTRACT

An electrical porcelain body of the composition 30% H and G Al china clay, 20% Dorset English ball clay, 20% Ottawa flint, and 30% Buckingham feldspar, fired to cone 11, showed a modulus of elasticity of $9.54 \pm 0.02 \times 10^6$ lb. per sq. in. (mean of 164 measurements). A similar body with Kentucky special ball clay substituted for Dorset ball clay gave a value of $10.01 \pm 0.02 \times 10^6$ lb. per sq. in. (mean of 69 measurements). The accuracy of the measurements was $\pm 1.5\%$. The use of the modulus as a measure on the uniformity of electrical porcelain gave excellent results. The variations were expressed in terms of statistical constants such as the standard deviation and the coefficient of variability.

I. Introduction

In connection with some research work on electrical porcelain it was found necessary to make a large number of measurements of the modulus of elasticity. An examination of the literature showed some scattered information which has been collected in the International Critical Tables.[2] This summary is rather unsatisfactory since the number of samples is indicated in only one case; the probable error of the mean is not mentioned; no measure of the dispersion is shown; and the firing conditions are not mentioned. A modulus of 8300 kg. per sq. mm. is given as the mean of 72 samples of Berlin hard porcelain. This is roughly 12×10^6 lb. per sq. in. A value of 10,600 kg. per sq. mm. (approximately 15×10^6 lb. per sq. in.) is given for G. E. porcelain. The number of samples is not stated.

The data and histograms given in this paper are likely to prove of interest and value since the literature on the subject is not voluminous.

II. Theory

If a material is stressed in one direction only, the unit-stress at any point is proportional to the unit-strain, provided that the unit-stress is equal to

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[1] The data presented in this paper were obtained in an investigation financed by the Utilities Research Commission, Inc., Chicago, Illinois. The experiments were conducted as part of the work of the Engineering Experiment Station of which M. S. Ketchum is the Director. This research was carried out in the Department of Ceramic Engineering of which C. W. Parmelee is the Head. The complete results of the investigation will be presented in a *Bulletin* of the Engineering Experiment Station, University of Illinois, Urbana, Illinois.

Received July 9, 1931.

[2] Frank H. Riddle, International Critical Tables, Vol. 2, p. 69. McGraw-Hill Book Company, New York (1927).

or less than the proportional limit of the material. Expressed mathematically, the result is:

$$E = \frac{s}{e} \tag{1}$$

Where E = modulus of elasticity
s = unit-stress
e = unit-deformation

For a cantilever beam the modulus is expressed by the equation[3]

$$E = \frac{Pl^3}{3I\Delta} \tag{2}$$

Where P = concentrated load on the free end
l = length of span
I = moment of inertia
Δ = deflection

This equation may be transformed into the form

$$E = \frac{64Pl^3}{3\pi\Delta d^4} = \frac{6.79Pl^3}{\Delta d^4} \tag{3}$$

Where d is the diameter of the beam if the cross-section is circular.

If a constant load, P, of two pounds is used, the final form of the equation becomes

$$E = \frac{13.58l^3}{\Delta d^4} \tag{4}$$

It is not difficult to perceive that equation (3) is of the form

$$E = K\frac{s}{\Delta} \tag{5}$$

which is equivalent to equation (1).

III. Experimental Procedure

(1) Preparation and Firing of Test Specimens

Two body compositions, which were identical with the exception that Dorset English ball clay was used in one body and Kentucky special ball clay was used in the other, were employed in this work. The proportions, as shown below, represent a typical electrical porcelain body.

Body A	%	Body B	%
H and G A1 china clay	30	H and G A1 china clay	30
Dorset ball clay	20	Kentucky special ball clay	20
Ottawa flint	20	Ottawa flint	20
Buckingham feldspar	30	Buckingham feldspar	30

[3] Fred B. Seely, Resistance of Materials. New York, John Wiley and Sons, Inc., pp. 168–69 (1925).

In preparing the test specimens, rods about 12 inches long were formed by extrusion through a die of $^1/_2$-inch diameter. To avoid warpage during drying the rods were run from the die directly into plaster of Paris molds (Fig. 1A), flattened at one end (Fig. 1B), a hole was made through the flattened portion, and the rods were allowed to dry in these molds. This procedure very effectively prevented any bending or warping and unusually straight specimens were obtained.

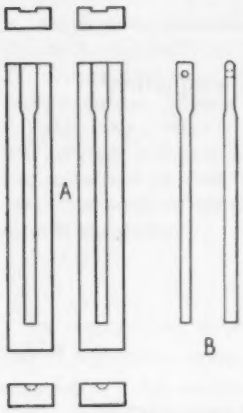

FIG. 1.—(A) Plaster mold in which the specimens were dried to prevent bending. (B) Shape of the rod after drying.

The method which was employed for firing the rods is shown in Fig. 2. Small pins of triangular cross-section were placed through the holes in the flattened parts of the rods which were suspended through a perforated disk supported on a deep sagger. A small sagger was inverted over the disk. This process of firing produced very straight rods. All of the specimens used in this work were fired to cone 11.

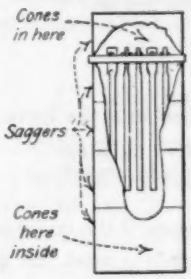

FIG. 2.—Method of placing rods in the kiln.

After firing, the flattened portion of each specimen was removed by means of a cutting wheel leaving rods of circular cross-section, about 0.4 inch in diameter and about 11 inches in length.

(2) Method of Measuring Modulus of Elasticity

The apparatus employed is shown in Fig. 3. The dial gage was graduated in ten-thousandths of an inch and this gave deflection readings of sufficient accuracy. The load on the free end of the bar was 2 pounds. In every case, the load was applied as near as possible to the contact between the rod and the spindle of the dial gage.

The value of Δ which was used for calculating the modulus of elasticity was generally the mean of five measurements. In case the agreement was good, only three readings were taken.

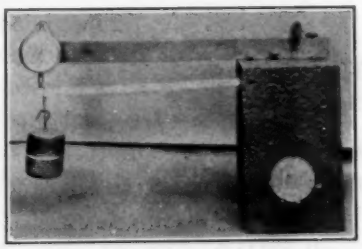

Fig. 3.—Apparatus used for measuring the modulus of elasticity.

IV. Discussion of Results

Series A, B, C, and D represent the results of four firings of Body A. Series E and F are two firings of Body B. Table I gives the values of the moduli of elasticity for the six series men-

tioned above. Series G and H are two commercial bodies used by a manufacturer of high-tension insulators. The details regarding body compositions as well as the method of preparing the specimens are unknown for

TABLE I

MEASUREMENTS OF THE MODULUS OF ELASTICITY OF ELECTRICAL PORCELAIN
(Multiply each measurement by the unit in order to obtain the modulus)
(unit = lb. per sq. in. $\times 10^6$)

Series A		Series B	Series E		Series F		Series C		Series D		Series G		Series H	
9.69	9.48	9.77	9.32	10.59	10.29		9.63	9.24	9.43	10.83	10.04	8.29	9.08
8.28	10.10	9.70	9.77	10.23	10.15		9.91	8.82	9.50	10.54	8.20	9.52	9.08
9.70	9.32	9.30	9.77	10.17	10.14		9.50	9.56	9.63	8.51	9.85	9.45	9.51
10.29	10.02	9.50	9.80	10.08	10.37		9.70	9.77	9.56	8.32	9.52	9.19	9.24
9.72	9.64	9.77	9.62	10.47	10.29		9.05	9.70		9.24	9.58	8.48	7.90
9.14	10.04	9.37		10.08	10.21		9.17	9.91	9.43	10.03	11.55	9.68	8.20
9.70	9.87		9.92	10.16	10.13		9.37	9.50	9.63	10.14	7.83	9.34	
8.91	9.84	9.18	9.79	10.29					9.77	10.04	8.30		
9.67	10.29	9.56	9.63		9.84		9.77	9.50	9.77	8.51		9.34	9.08
9.72	10.38	9.70	9.64	10.26	10.22		9.50	9.63				9.04	7.74
9.03	10.11	9.37	9.43	10.35	10.37		9.91	9.98	9.43	9.34	9.34	8.87	9.43
9.58	9.94	9.98		9.88	10.13		9.50	9.43	9.98	9.25	10.80	9.13	9.00
			9.99	9.93	10.45		9.63	9.11	9.70	9.25	9.40	9.85	10.21
9.56	9.26	9.11	9.46	9.93	10.29		9.77	9.45	10.13	9.50	10.53	9.20	9.68
9.60	10.35	9.43	9.58	10.29	10.45		9.50			9.44	9.97	9.34	
10.08	9.68	9.50	9.96	10.53					9.63	9.07	9.09		
9.11	8.15	10.13					9.24	9.18	10.21	8.69	9.84	9.50	8.75
8.94	9.32	10.29	9.64	9.41			9.50	9.50	9.43	10.03	7.97	8.11	9.19
10.09	8.58		9.98	10.15			9.50	9.84		10.89		9.45	7.74
9.73	7.79	9.70	9.92	9.89			9.56	9.24	9.77			8.91	9.51
9.78	8.92	9.70	10.08	9.62			9.56	9.63	10.29	9.05	9.40	8.97	8.85
9.34	8.24	9.43		10.39			9.50	9.50	9.50	10.83	10.31	8.74	8.65
9.47	8.29	9.77	9.84	9.93			9.43			11.30	9.85	9.12	
10.05	8.65	9.50	9.83	10.24					10.05	9.51	8.78		
9.93	8.62		9.64						10.13	9.58	9.40		
		9.24	9.86	10.29					9.77	10.72	10.02		
9.42	9.60	9.11		10.29						9.44	10.04		
9.74	9.35	9.84	9.99	9.98						10.31	9.35		
10.13	8.87	9.70	9.58	9.91						10.63			
9.98	9.00	9.84	9.82	10.39									
9.31	9.22		9.86	10.21									
9.70	9.22	9.84		9.70									
9.78	9.13	9.56											
9.72	8.94	10.21											
9.61	8.34	9.56											
9.39	8.81	9.91											
10.46	9.31												
9.93	9.46												

these series. The specimens were fired to cone 11 in a kiln containing porcelain insulators.

Table II shows the data grouped in the proper manner for plotting the histograms shown in Figs. 4 to 8. Table V summarizes the data obtained. Series ABCD is a composite of series A, B, C, and D. Series BC combines the data of series B and C, while series EF combines the data of series E and F.

In any series there is considerable dispersion although nearly all of the laboratory samples show less than do the commercial specimens. The probable error of a single observation (*p.e.*) is a measure of the dispersion in each series but the coefficient of variability (*C*) is a better constant to use since it takes into account variations in the arithmetic mean. Series A shows a rather high value for *C* when compared with some of the other series. The plant specimens, series G and series H, show relatively large dispersions, the values of *C* are 9.03 and 6.33%, respectively. The values of *C* for series B, E, F, C, and D are of the same order of magnitude and may be considered as good agreement. Series BC and series EF show good agreement, which allows them to be compared with each other.

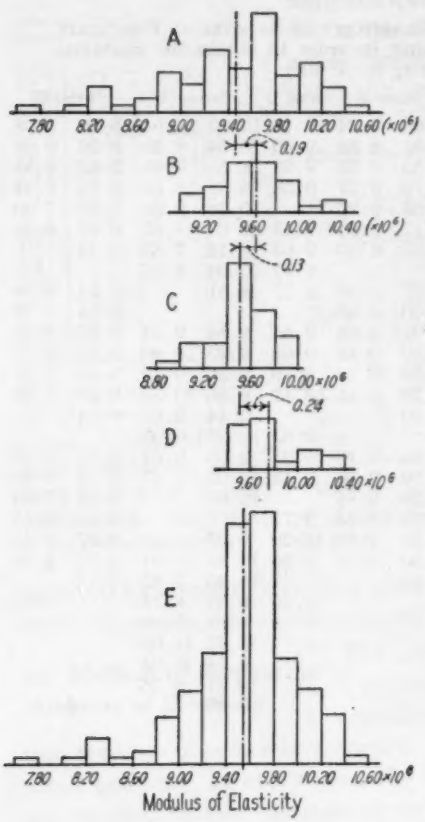

FIG. 4.—Dispersion of modulus of elasticity of cone 11 electrical porcelain containing Dorset English ball clay. (A) Series A. (B) Series B. (C) Series C. (D) Series D. (E) Series ABCD (composite of the first four series).

In spite of the care used in the fabrication of the test specimens, the values of the modulus of elasticity still showed fairly large dispersions because of failure to reproduce exactly all of the conditions which control the preparation of the specimens.

The mean values of the moduli for series A, B, C, and D are 9.45 ±0.04, 9.64 ±0.04, 9.51 ±0.03, and 9.75 ±0.04 ($\times 10^6$ lb. per sq. in.), respectively. The question arises as to whether or not these differences are significant. A statistical answer is possible and it involves the following method of reasoning.

A term *Z* may be defined as the ratio between the difference of any two mean values and the probable error of the difference. Expressed as an equation the result is

$$Z = \frac{m}{e} = \frac{\overline{X}_2 - \overline{X}_1}{\sqrt{(P.E.)^2_1 + (P.E.)^2_2}}$$

TABLE II

MEASUREMENTS OF THE MODULUS OF ELASTICITY OF ELECTRICAL PORCELAIN (GROUPED DATA)

Number of measurements in each class interval = f

$E \times 10^{-4}$	Series A (Fig. 4A)	Series B (Fig. 4B)	Series C (Fig. 4C)	Series D (Fig. 4D)	Series F (Fig. 5B)	Series E (Fig. 5A)	Series ABCD* (Fig. 4E)	Series BC* (Fig. 6A)	Series EF* (Fig. 6B)	Series G (Fig. 7A)	Series H (Fig. 8A)
7.70	1						1				2
7.90	0						0			2	1
8.10	1						1			0.5	1.5
8.30	4						4			2.5	1.5
8.50	1						1			2	1
8.70	2						2			2	3
8.90	6.5		1				7.5	1		0	4.5
9.10	4.5	3	4				11.5	7		3	9
9.30	10	4	4			1	18	8	1	7.5	4.5
9.50	7	8	17	7	1	4	39	25	5	8.5	7
9.70	16	8	9	8	2	8.5	41	17	10.5	0	2
9.90	6	5	5	1	8	11.5	17	10	19.5	4	1
10.10	8	1		3	9	1	12	1	10	7	0
10.30	4	2		2	18		8	2	18	1	1
10.50	1				5		1		5	2	
10.70										2.5	
10.90										3.5	
11.10										0	
11.30										2	
11.50										1	
Totals	72	31	40	21	43	26	164	71	69	51	39

E = modulus of elasticity in lb. per sq. inch.

f = frequency, or the number of samples which fall within each class interval. The decimals result from the fact that a measurement falling on a class boundary is considered as being partly in each of the two classes. Thus, for a measurement of 9.40 we would add 0.5 to the 9.30 class and 0.5 to the 9.50 class.

The series marked by an asterisk above are formed by combining two or more other series. Thus, Series ABCD is a composite of Series A, B, C, and D. Series BC is a composite of Series B and C. Series EF is a composite of Series E and F.

From the properties of the probability curve the following data[4] can be calculated.

$Z = \frac{m}{\sigma}$	Odds against the occurrence of a ratio greater than Z
1	1 to 1
2	4.6 to 1
3	21 to 1
4	142 to 1
5	1300 to 1
6	20,000 to 1
9	1,000,000,000 to 1

Applying the above method to the data given in this paper gives the following results:

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[4] (*a*) Lovett and Holtzclaw, Statistics. Prentice-Hall, N. Y., pp. 279–80 (1929).

(*b*) Handbook of Mathematical Statistics. H. L. Rietz, Editor-in-Chief, Houghton Mifflin, N. Y., p. 100 (1924).

(*c*) Yule, An Introduction to the Theory of Statistics. Griffin, London, p. 311 (1927).

Series	Z	Odds
B and A	3.32	32 to 1
B and C	2.89	17 to 1
B and D	1.98	4.6 to 1
A and D	4.92	1000 to 1
A and C	1.16	1.3 to 1
C and D	4.78	800 to 1
E and F	10.8	Over 1,000,000,000 to 1

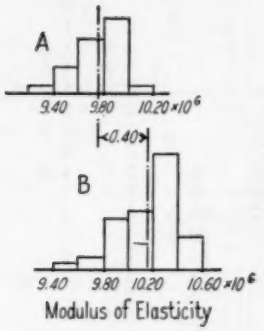

FIG. 5.—Dispersion of modulus of elasticity of cone 11 electrical porcelain containing Kentucky special (American) ball clay. (A) Series E. (B) Series F.

The differences between series A and D, between C and D, and between E and F can be considered to be significant in view of the above calculations. Series D consisted of only 21 samples; the histogram (Fig. 4D) shows a very poor distribution. The number of samples was entirely too small to give a correct estimation of the mean. It seems reasonable then to disregard the significant differences between the mean of this series and the means of series C and A.

The same reasoning may be applied to the difference between the means of series E and series F, since series E consisted of only 26 samples. Again in this case the histogram (Fig. 5A) does not show a very normal distribution.

Series F and series C were fired together. When these means were compared a value of approximately 17 was found for Z and the odds are almost ∞ to 1 that the difference is significant. It would seem that the Kentucky special ball clay resulted in a higher modulus but a larger number of samples should be used to verify this result.

The large dispersions of series G and H show that the conditions of preparation and firing of the specimens were not as uniform as in the case of the laboratory samples.

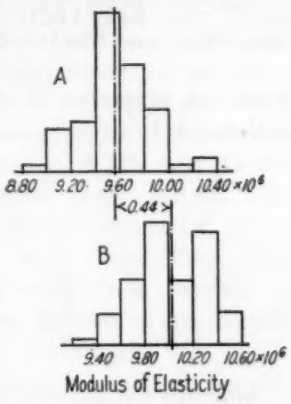

FIG. 6.—Comparison between English (Dorset) and American (Kentucky special) ball clays in cone 11 electrical porcelain. (A) composite of Series B and C. (B) Composite of series E and F.

V. Summary

(1) Most measurements of the modulus of elasticity of ceramic materials are based upon an insufficient number of samples. The values of $9.54 \pm 0.02 \times 10^6$ lb. per sq. in. (Body A, 164 measurements) and $10.01 \pm 0.02 \times 10^6$ lb. per sq. in. (Body B, 69 measurements) are satisfactory in this respect.

(2) The results given in this paper are subject to a maximum error of 1.5% because of limitations in the accuracy of the measurements used in the calculation of the moduli.

(3) The utility of so-called "critical constants" for ceramic materials is extremely limited unless accompanied by careful descriptions of the composition, preparation, firing conditions, etc. In addition, it is almost necessary to include some measure of the dispersion about the arithmetic mean.

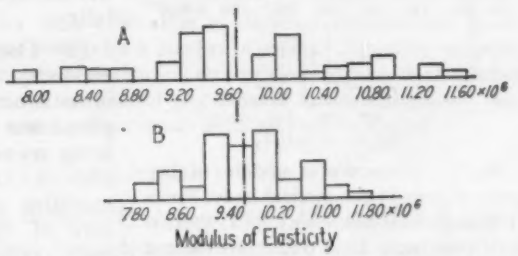

FIG. 7.—Dispersion of modulus of elasticity of cone 11 commercial electrical porcelain. Series G (composition unknown). (A) Plotted with class interval of 0.2. (B) Plotted with class interval of 0.4.

(4) The use of Kentucky special ball clay instead of Dorset English ball clay in the porcelain used in this paper resulted in a higher value of the mean modulus of elasticity. The number of samples used was not large enough to permit the statement of a formal conclusion regarding the substitution of ball clays but the present data indicate rather definitely that the above result represents the true condition.

TABLE III

SUMMARY OF STATISTICAL ANALYSIS OF DATA ON MODULUS OF ELASTICITY OF ELECTRICAL PORCELAIN FIRED TO CONE 11

(unit = lb. per sq. inch $\times 10^6$)

Series	N	$\overline{X}$	*p.e.*	*P.E.*	C (%)
A	72	9.45	0.369	0.044	5.79
B	31	9.64	0.199	0.036	3.07
E	26	9.76	0.134	0.026	2.04
F	43	10.16	0.170	0.026	2.48
C	40	9.51	0.171	0.027	2.66
D	21	9.75	0.187	0.041	2.84
ABCD	164	9.54	0.303	0.024	4.72
BC	71	9.57	0.188	0.022	2.81
EF	69	10.01	0.206	0.025	3.04
G	51	9.67	0.589	0.083	9.03
H	39	9.04	0.386	0.062	6.33

N = number of samples in the series
$\overline{X}$ = arithmetic mean
p.e. = probable error of a single observation
P.E. = probable error of the arithmetic mean
C = coefficient of variability = $\dfrac{p.e.}{0.6745\overline{X}} \times 100$

(For definitions of the statistical terms used, see A. E. R. Westman, *Jour. Amer. Ceram. Soc.*, **10**, 133–47 (1927); Robert F. Ferguson, *ibid.*, **13**, 354–62 (1930); Handbook of Mathematical Statistics, H. L. Rietz, Editor-in-Chief, Houghton Mifflin Company, 1924.)

(5) The use of the modulus of elasticity as a measure of the uniformity of electrical porcelain gives excellent results. The variations or dispersions may be expressed in quantitative manner by means of the standard deviation and the coefficient of variability.

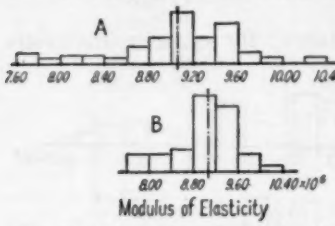

FIG. 8.—Dispersion of modulus of elasticity of cone 11 commercial body, Series H (composition unknown). (A) Plotted with class interval of 0.2. (B) Plotted with class interval of 0.4.

(6) The use of the modulus of elasticity as a measure of uniformity is satisfactory but for practical applications it should be coupled with some measurement such as the tensile or transverse strength. The modulus of elasticity gives a measure of the uniformity of a specimen considered as a whole; tensile strength gives an indication which depends upon the point of greatest weakness in a specimen.

Acknowledgment It is a pleasure to acknowledge the advice of C. W. Parmelee, Head of the Department of Ceramic Engineering.

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MECHANICAL AND THERMAL SHOCK TESTS ON CERAMIC INSULATING MATERIALS[1]

By H. M. Kraner and R. A. Snyder

ABSTRACT

Simple tests, as developed for daily production of electrical porcelain are given. Laboratory tests are described and results for a number of ceramic insulating materials are given. From these it is shown that mechanical strength and resistance to thermal shock are valuable indications of the mechanical properties of bodies and glazes. Results obtained in testing foreign- and American-made porcelains are compared.

I. Introduction

Mechanical strength and uniformity are perhaps the most important considerations in high-voltage insulator manufacture, and the trend of modern design is demanding porcelain capable of withstanding increasingly severe service.

To obtain and maintain such improvement, a continuous check of porcelain quality is essential. Daily tests are necessary, and it was with this in view that all porcelain tests were reviewed and simple tests were sought. The following points were considered in connection with present available tests and technique in developing desirable plant laboratory tests for routine testing.

II. Outline of Porcelain Tests

(1) Tensile Strength Standard methods[2] have been devised for determining tensile strength of porcelain but considerable difficulty is encountered in preparing uniformly straight test specimens and in doing this economically. Testing is slow and tedious if uniform accurate results are to be obtained. Unit tensile stress of ceramic materials varies with the area of cross-section of the specimen,[3] a condition which would cause difficulty if it were found necessary to employ test pieces of varying dimension. In general, therefore, tensile testing would not be a satisfactory routine test to evaluate the daily product.

(2) Compressive Strength Considerable data are available on compressive strength measurement. As in the case of tensile stress, the size of specimen is quite important, and accuracy of values is largely dependent upon preparation of test specimens and skill of the operator in testing.

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[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (White Wares Division).

[2] Standards Report, *Jour. Amer. Ceram. Soc.*, **11** [6], 468–71 (1928).

[3] L. Navias, "Methods of Testing and the Physical Properties of Wet-Process Electrical Porcelain," *Jour. Amer. Ceram. Soc.*, **9**, 501–10 (1926).

(3) Impact Strength No entirely satisfactory method of measuring impact strength of ceramic materials has been developed. Tests which utilize the falling hammer principle[4] yield values which are comparative for a particular test specimen but do not give values in absolute units. Data obtained on a machine of the Charpy pendulum type are largely empirical, being dependent upon various factors such as speed of hammer, diameter and length of specimen, specific gravity, etc. In general this test has not been found comparative.

(4) Modulus of Rupture Modulus of rupture or cross-breaking strength is apparently the logical physical property to choose in continuous testing for the following reasons:

(1) Uniform specimens are very easily produced.
(2) Testing procedure is simple and rapid.
(3) The results are practically independent of area of cross-section of specimen.

III. Mechanical Tests

In selecting a standard test specimen, the modulus of rupture values obtained from round and square bars, machine-made, and hand-molded square bars were compared. Machine-made round bars were considerably more uniform and gave the higher values. These were formed by extruding plastic clay through the die of an extrusion machine consisting of a cylinder and electrically driven plunger. The following table gives values obtained in testing these various types of specimens:

TABLE I

MODULUS OF RUPTURE

	Hand-molded (½-in. square)	Machine-made (½-in. square)	Machine-made (½-in. round)
	6670	10500	13380
	5690	7640	12260
	10540	10440	12770
	10390	10710	12500
	8480	10970	13400
	5950	11040	13140
	8890	9910	12230
	9640	12690	13400
	9340	11350	12340
	8710	8050	13480
	6840	10190	
	7000	11290	
Av. modulus (lb./sq. in.)	8180	10400	12890
Av. deviation from mean (%)	17.8	10.1	3.65

These values show the deficiency of square test specimens with regard to uniformity and the probable error which may be expected. The tendency

[4] Standards Report, *loc. cit.*, pp. 473–74 (1928).

of square bars to warp during firing, which gives rise to poor stress distribution in testing is probably largely responsible for the low values obtained.

The machine-made round bars were very uniform, with an average deviation from the mean of only 3.65%. A machine-made round test specimen was therefore adopted for standard daily routine tests, $^3/_4$ inch in diameter and 6 inches in length, fired dimensions.

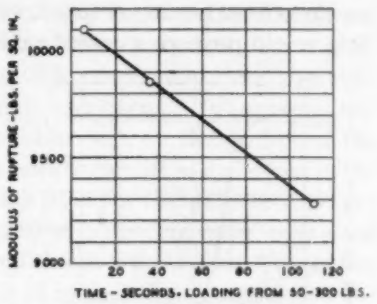

FIG. 1.—Modulus of rupture showing effect of speed of loading on strength of porcelain bars.

A late model Olsen testing machine is used for modulus of rupture testing. The distance between supports is 5 inches, the load being transmitted to the specimen at the middle by means of a flexible steel cable, thus assuring uniform stress distribution at the point of contact. The machine is provided with a ratchet device which permits imposing a uniform initial load on the specimen. This load is maintained at 50 pounds. The rate of application of load may also be controlled. Figure 1 shows the effect of speed of loading on modulus of rupture values of a porcelain. A standard speed has been adopted so that approximately 15 seconds are required to increase the load from 50 to 300 pounds. Auxiliary attachments are provided for the machine which permit varying the span and testing square bars. Modulus of rupture may be calculated from the formula:

$$M = \frac{8PL}{\pi D^3}$$

where M = modulus of rupture (lb./sq. in.)
P = load (lb.)
L = span (inches)
D = diameter (inches)

A chart has been developed from which, given the diameter and breaking load of a specimen, the modulus of rupture may be read directly. This is not convenient with square bars. The average of 10 values is reported.

IV. Thermal Shock

Due to the importance of the ability of electrical porcelain to withstand thermal shock, the daily test was expanded to include a measure of this property. A standard test has been given[5] which consists of repeated transferring of the specimen from boiling water to ice water until failure occurs. Such a test is time-consuming and was considered less significant than one which determined the loss of strength on quenching. The $^3/_4$-inch

[5] Standards Report, *loc. cit.*, p. 475 (1928).

bars were quenched from a number of successively higher temperatures and modulus of rupture tests were made (Fig. 2). The curve indicates a rapid loss of strength by the porcelain as quenching temperature rises. The standard quenching temperature of 150°C was adopted since this temperature lies on the critical portion of the curve and small changes in quality of the porcelain would produce a considerable effect on loss of strength on quenching. Specimens for heat-shock tests are placed in an automatic temperature-controlled oven for 18 to 24 hours, then quenched in ice water. Cross-bending tests on the quenched bars are made and the average of 10 values reported.

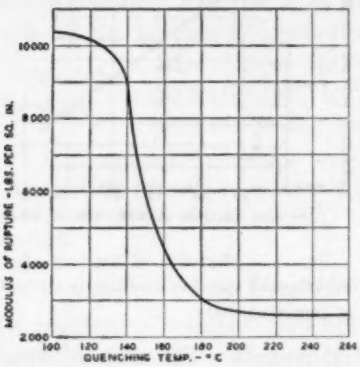

FIG. 2.—Strength of $^3/_4$-inch round bars quenched at °C from temperature indicated.

V. Laboratory Testing

Inasmuch as it is generally more convenient to work with smaller volumes of material in experimental work, a smaller machine-made test piece has been adopted, which is approximately $^1/_2$ inch in diameter by 3 inches long, fired dimensions. These bars are tested on the $2^1/_2$-inch span of a hydraulic cross-breaking machine. As in the case of the Olsen machine described above, a flexible steel cable transmits the load. In addition to testing the unquenched bars, tests are also made on specimens quenched from 200°, 300°, and 400°C into water at room temperature. The average of 10 values for each group is reported. Figure 3 shows graphically the test values for a number of interesting ceramic materials.

VI. Summary of Tests

(1) Glaze Fit Application of a well-designed glaze adds considerable strength to a porcelain[6] and resistance to thermal shock is improved.[7] This is demonstrated by the results shown in Fig. 3 for standard American electrical porcelain. Here the unglazed porcelain has a modulus of rupture of 12,300 lb. per sq. in. as compared with 14,800 lb. per sq. in. for the 100% glazed bar (normal thickness of glaze), an increase of approximately 20% and at the same time resistance to heat shock becomes much greater.

An example of imperfect glaze fit may be seen in German porcelain C.

[6] Riddle and Laird, "The Control of Glaze Fit by Means of Tensile Test Specimens," *Jour. Amer. Ceram. Soc.*, **5**, 499 (1922).

[7] Handrek, "Working Properties of Electrical Porcelain," *Keramos*, 7 [T$_8$], 13 (1928).

This material has a modulus of rupture of 12,800 lb. per sq. in. when unglazed with a fairly high strength (10,500 lb. per sq. in.) when quenched at 200°C. The glaze applied to this body, however, brought about a loss of strength of 16% and seriously reduced resistance to heat shock.

In some cases, as in German porcelain A, the glazed specimens appeared stronger after quenching from 200°C than when unquenched.

(2) Types of Quenching Failure Two distinct types of fracture have been observed on testing quenched specimens. In some cases, very fine cracks could be seen on the surface of the glazed pieces. On breaking, a somewhat hackly condition was noted in the outer portion of the bar with lines radiating from the circumference toward the center of the bar, the depth of penetration depending upon severity of the thermal shock. Such a shattering condition is typical of most quenched specimens. It is probably due to more rapid cooling of the surface over the

TABLE II

CHEMICAL ANALYSES OF CERAMIC MATERIALS (1929 COMPOSITIONS)

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O
Standard American porcelain	71.30	20.96	1.92	0.76	0.24	0.58	3.53	0.78
German porcelain A	74.18	21.16	0.22	0.19	0.05	0.27	3.52	0.46
German porcelain B	73.28	22.48	0.96	0.14	0.06	0.14	2.62	0.76
German porcelain C	74.30	19.37	0.97	0.16	0.22	0.09	3.73	1.19
Steatite (plastic process)	66.08	5.13	0.82	0.10	0.10	27.32	0.42	0.28
Melalith*	72.41	24.27	0.64		0.08	0.47	2.13	2.13
Sillimanit†	67.20	25.67	0.81	0.64	0.20	0.32	4.22	1.36
American chemical stoneware	66.54	24.55	3.50	1.45	0.10	0.72	2.56	0.57

* Melalith, a typical porcelain containing a trace of intentionally added MgO as talc.
† Sillimanit (not sillimanite), a clay body similar to American chemical stoneware but of better strength and dielectric properties.

interior at the instant of quenching. This shattering effect became more pronounced in the case of some glazed materials.

Characteristic failure of some glazed materials on quenching, for example, steatite and melalith, was by cracking parallel to the axis of the cylindrical test specimen, generally with complete loss of strength. In this case the coefficient of expansion of the glaze apparently is less than that of the porcelain, hence the glaze is probably subjected to compressive stresses.

(3) Glaze Thickness Gerold[8] has shown that the strength imparted to porcelain by a glaze varies directly with thickness of glaze. He removed the glaze from specimens by grinding and found the modulus of rupture practically the same as for unglazed specimens, although the elasticity coefficient remained somewhat higher. Thus, a very thin glaze coating was applied to the standard American electrical porcelain by dipping the specimens in a mixture of 10% normal

[8] E. Gerold, "Influence of the Glaze upon the Physical Properties of Porcelain," *Keram. Rund.*, 33, 188–90 (1925).

glaze and 90% water. The modulus of rupture was practically unaffected, but loss of strength on quenching is greatly reduced. A 50% normal glaze coating that is approximately half of the usual thickness raises the

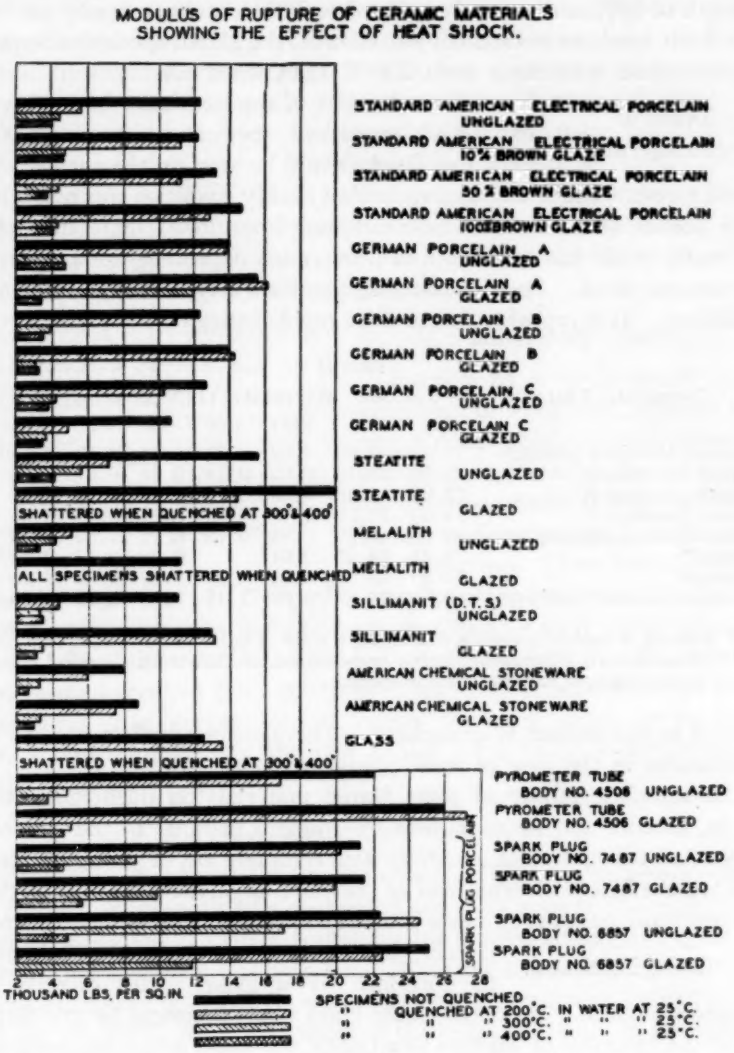
MODULUS OF RUPTURE OF CERAMIC MATERIALS
SHOWING THE EFFECT OF HEAT SHOCK.
STANDARD AMERICAN ELECTRICAL PORCELAIN UNGLAZED
STANDARD AMERICAN ELECTRICAL PORCELAIN 10% BROWN GLAZE
STANDARD AMERICAN ELECTRICAL PORCELAIN 50% BROWN GLAZE
STANDARD AMERICAN ELECTRICAL PORCELAIN 100% BROWN GLAZE
GERMAN PORCELAIN A UNGLAZED
GERMAN PORCELAIN A GLAZED
GERMAN PORCELAIN B UNGLAZED
GERMAN PORCELAIN B GLAZED
GERMAN PORCELAIN C UNGLAZED
GERMAN PORCELAIN C GLAZED
STEATITE UNGLAZED
STEATITE GLAZED
MELALITH UNGLAZED
MELALITH GLAZED
SILLIMANIT (D.T.S) UNGLAZED
SILLIMANIT GLAZED
AMERICAN CHEMICAL STONEWARE UNGLAZED
AMERICAN CHEMICAL STONEWARE GLAZED
GLASS
SHATTERED WHEN QUENCHED AT 300° & 400°
ALL SPECIMENS SHATTERED WHEN QUENCHED
SHATTERED WHEN QUENCHED AT 300° & 400°
PYROMETER TUBE BODY NO. 4508 UNGLAZED
PYROMETER TUBE BODY NO. 4506 GLAZED
SPARK PLUG BODY NO. 7487 UNGLAZED
SPARK PLUG BODY NO. 7487 GLAZED
SPARK PLUG BODY NO. 6857 UNGLAZED
SPARK PLUG BODY NO. 6857 GLAZED
SPARK PLUG PORCELAIN
2 4 6 8 10 12 14 16 18 20 22 24 26 28
THOUSAND LBS. PER SQ. IN.
SPECIMENS NOT QUENCHED
" QUENCHED AT 200°C. IN WATER AT 25°C.
" " 300°C. " " " 25°C.
" " 400°C. " " " 25°C.

FIG. 3.

modulus of rupture 9%, while the standard glaze coating gives an increase of 20% over the unglazed materials.

(4) Steatite Glazing Steatite, is a material high in magnesia, is used where higher mechanical strengths are desired.

Such compositions cannot be satisfactorily glazed with ordinary porcelain glazes, hence the necessity of special glazes, which apparently are not as desirable as ordinary porcelain glazes on single-fired porcelain. This is clearly shown by the fact that both steatite and melalith, when glazed, suffer complete loss of strength on quenching.

(5) Spark Plug Porcelains The results given in Fig. 3 clearly show that the spark plug porcelains are more satisfactory in regard to high mechanical strength and heat-shock resistance than any of the various materials tested. Such porcelains require higher firing temperatures than steatite, but have longer firing ranges.

Conclusions

(1) Methods of preparing test specimens and conducting tests have been found which yield highly uniform results.

(2) Simple tests have been developed for daily production of electrical porcelain which give valuable information.

(3) The tests devised have been adapted to testing of new materials.

(4) Tests developed, when conducted on both glazed and unglazed specimens, indicate glaze-fit or value of the glaze itself.

(5) A number of materials have been tested and the data given. These permit the following observations:

(*a*) Of a group of foreign-made porcelains which have been tested, one shows a slight superiority, as to mechanical strength and resistance to thermal shock over a standard American electrical porcelain, while the others are inferior.

(*b*) American spark plug porcelains of the mullite type are vastly superior to all other ceramic materials tested as to mechanical strength, thermal-shock resistance, and glaze-fit.

(*c*) A well-designed glaze adds greatly to the mechanical strength and resistance to thermal change of porcelain.

(6) Chemical analyses of German and American porcelains do not differ widely. From this and other data given it is concluded that firing to a relatively higher temperature for a short period (usual European practice) apparently offers no advantage over firing at a lower temperature for a longer time.

Acknowledgment The authors wish to express their appreciation to the Champion Porcelain Company for supplying the spark plug and pyrometer tube porcelain test specimens referred to in this paper.

WESTINGHOUSE ELECTRIC & MFG. CO.
DERRY, PA.

METAL MARKING OF WHITEWARE GLAZES AS INFLUENCED BY SULPHUR AND CARBON IN KILN ATMOSPHERES[1]

By R. F. Geller and A. S. Creamer

ABSTRACT

A study was made to determine the causes which make glaze surfaces susceptible to marking by metallic objects. The effect of carbon monoxide and of varying concentrations of SO_2 gas in the furnace atmosphere at 860°C, was investigated. It was found that (*a*) carbon monoxide does not produce surfaces which metal mark; (*b*) concentrations of from 0.1 to 1.2% SO_2 increase susceptibility to scratching with metals; (*c*) SO_2 in concentrations of 3% and higher will destroy the gloss of glazes on typical hotel ware and earthenware; and (*d*) concentrations of SO_2 of 3 to 12½% cause the glaze on one vitreous low-fired type of ware to metal mark.

I. Introduction

When metallic objects such as silver-plated knives are drawn across tableware, a "mark" is produced occasionally which cannot be removed easily. These marks resemble lines made with a lead pencil on paper. They can be made without exerting any more pressure on the metal than would normally be used in writing with a hard lead pencil, and the more expensive grades of ware may be just as susceptible to marking as the cheaper grades. One of the simplest and most reasonable assumptions as to the immediate cause of this type of marking is that certain conditions had caused a roughening of the glaze surface with a consequent abrasion of metal objects when drawn across the roughened surface. On this basis a study was made to determine the probable causes and the following four possibilities considered:

(*a*) The decomposition of sulphates in the glaze or body resulting in the evolution of gas and the formation of microscopic pits and bubbles in or at the surface of the glaze.
(*b*) The surface of the glaze not being fused to smoothness.
(*c*) The formation of a superficial coating caused by reducing conditions in the kiln and augmented by the presence of the organic compounds (oils) used in decorating the ware.
(*d*) The formation of a sulphate scum, and consequently a roughened surface, because of SO_2 in the kiln atmosphere.

Careful supervision of plant conditions to eliminate the first two causes did not prevent the marking. Furthermore, these causes should produce defects noticeable after the gloss fire as well as after the decorative fire. Since the susceptibility to marking could be eliminated by buffing, since it was found to a lesser degree with ware fired in a well-ventilated kiln, and

[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (White Wares Division). Received March 23, 1931.

Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

since sulphur oxide gases are almost invariably present in the atmosphere of all but electrically heated furnaces, the third and fourth possibilities seemed the more logical ones. Accordingly, a study was made to determine the effect of carbon monoxide, and of varying concentrations of sulphur (introduced as SO_2) necessary to produce this condition.

A pottery submitted a large number of undecorated plates together with samples of a groundlay, Dresden thick, tinting, and decalcomania oil. In addition a large variety of ware submitted by manufacturers for other tests were available in the Bureau. The oils were submitted for use in connection with the study of the third possibility mentioned.

II. Procedure and Results

(1) Effect of Reduction by Carbon Monoxide

Thirty small glazed plates of vitreous ware were tested, as received from one manufacturer, for susceptibility to marking with various metals and alloys.[2] It was found that all of them were marked by aluminum, ten by lead, and four by tin. None of them could be marked with any of the other metals. Each plate was then broken into four pieces and one piece of each plate was painted with one of the decorating oils and fired in an electrically heated furnace to 860°C (1580°F) in an atmosphere containing carbon monoxide. The temperature of 860°C was used as a temperature within the range used commercially in decorating kilns. To obtain the carbon monoxide, pieces of wood were introduced through a small opening in the furnace door. Although this treatment had darkened the glaze by reduction of the lead to an extent which would have made ware of similar appearance unmarketable, it had not altered the susceptibility of the surfaces to marking.

(2) Effect of SO_2 in Furnace Atmosphere

It has been known for some time that a glaze surface susceptible to metal marking may be produced by sulphates introduced from impurities in the body or glaze components.[3] Sulphates in the glaze or body may also be derived from salts dissolved in the blunging and slip water. The blistering and other defects of ceramic finishes caused by "sulphuring" have been the subject of study and discussion since the time of Seger.[4] The "sulphuring" described by Seger and numerous writers since his time is generally evidenced by blisters, "glaze gall," matness, etc., easily seen with the unaided eye. All of these defects cause roughing of the glaze surface. It was assumed that sulphuring in less advanced stages, the

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[2] The metals and alloys used for marking were aluminum, lead, nickel, zinc, tin, copper, iron, steel, pure silver, a soft solder, a bronze, a brass, a German silver, and monel metal.

[3] H. E. Ashley, "Cutlery Marks on Glaze," *Trans. Amer. Ceram. Soc.*, **13**, 226 (1911).

[4] The Collected Writings of Hermann A. Seger, Vol. II, p. 645.

effects of which could not be detected by macroscopic examination, might produce surfaces roughened sufficiently to be marked with metals. That this roughing of a glass surface is possible at relatively low temperatures and with very small concentrations of SO_2 in the furnace atmosphere was demonstrated for vitreous enamels by Andrews and Hertzell.[5]

Accordingly, an apparatus was devised whereby sulphur dioxide gas could be introduced in small but definitely controlled amounts into an electrically heated laboratory furnace. The flow of air was controlled by means of a needle valve and measured with a mercury flowmeter which was calibrated before each test run. The flow of air could be controlled with an accuracy of ± 1 part in 400 parts. The flow of SO_2 gas was also controlled with a needle valve and the amount of flow determined either by counting the bubbles of gas escaping through a water-trap or by means of an oil flowmeter. To obtain the desired concentrations of SO_2 the air flow was varied from 32 liters to 666 ml. of air per minute and the gas flow from 1 to 500 ml. per minute. The "bubble" method was used for determining the flow of SO_2 gas in the range of 1 to 8 ml. per minute, while the oil flowmeter was used for the higher rates of flow. To facilitate distribution of the air-gas mixture throughout the furnace, the air and the gas were run through a common tube connected with a porcelain pyrometer protection tube, provided with a row of one-eighth inch perforations, which extended from the front to the back wall of the furnace.

Between each test run the furnace was heated to 850 to 900°C and, while holding in this temperature range, was thoroughly "washed" with a stream of fresh air in order to carry out any sulphur oxides which had been absorbed by the furnace walls during the previous test.

(a) First Series of Tests Specimens of six brands of vitreous ware (one of which was of European manufacture) and five brands of earthenware, none of which would mark as received were subjected to a series of ten tests in which they were thoroughly washed, heated to 860°C and, while being held at this temperature for one-half hour, were exposed to the following concentrations of SO_2: 0.003, 0.006, 0.012, 0.025, 0.05, 0.10, 0.20, 0.40, 0.80, and 1.20%.[6] The same specimens were used for the entire series and, after each exposure, they were permitted to cool in the furnace and were tried with silver, nickel, and steel for susceptibility to marking. The softer metals such as lead, tin, and aluminum were not used, because marks left by them can be removed

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[5] A. I. Andrews and E. A. Hertzell, "Progress Report on the Effect of Furnace Gases on the Quality of Enamels," *Jour. Amer. Ceram. Soc.*, **13** [8], 522 (1930).

[6] According to F. G. Jackson, a high average concentration of sulphur gases from coal in kiln gases, using 100% excess air, would not exceed 1%. "A Chemical Study of the Absorption of Sulphur Dioxide from Kiln Gases by Ceramic Ware," *Jour. Amer. Ceram. Soc.*, **9** [3], 154 (1926).

easily and completely. The specimens were then washed to determine whether or not the marks could be removed easily, again tried with the three metals, and rewashed. For SO_2 concentrations of 0.10% and less, it was found to be practically impossible to produce a mark or a scratch after the surface had been washed.[7] As the concentration of SO_2 was increased above 0.10% a gradually increasing susceptibility to marking was noted. This "marking," however, was really produced by scratching the glaze, the scratches becoming filled with the metal. This should not be confused with the "cutlery marks" or "metal marks" considered in this investigation.

FIG. 1.—Photomicrograph (magnification 170×) of a metal mark produced on a glazed surface which had been dried by heating at 600°C in an atmosphere free of SO_2.

By closely examining the specimens subjected to from 0.10 to 1.2% SO_2, it could be seen that minute bubbles had formed and broken at the glaze surface. The resultant pits were too small and scattered to be harmful except for specimens of one brand of ware. This ware consisted of a colored vitreous body and the usual transparent glaze. Blisters began to appear on this glaze with SO_2 concentrations as low as 0.025% and, after the series of tests were completed and the specimens had been exposed to 1.2% SO_2, the surface was decidedly rough and unsightly. The surface between blisters, however, could not be marked.

[7] In the course of this study a secondary phenomenon was observed which is of considerable importance to any one studying cutlery marking. It was noted that the surfaces could be marked after every test if the marking was tried shortly after the specimens were removed from the oven and before they had been washed. All of the specimens from this, as well as the second, series of tests would mark when removed from the oven. Obviously, this temporary susceptibility to marking could not be due to the same surface condition as that noted on commercial ware in service. Specimens were tested after having been heated at temperatures varying from 100 to 900°C, at 100-degree intervals. It was found that glazed surfaces heated to 600°C and 700°C would mark readily upon removal from the furnace, while those heated at 400°, 500°, 800°, and 900° would also mark, although less readily. This susceptibility to marking was lost after several hours exposure to the atmosphere. It was determined by test that duplicate specimens of the same brands of glazed ware when removed from the furnace while hot, and permitted to cool in a closed desiccator over P_2O_5, retained this susceptibility to marking even after as much as one week's storage. These specimens were heated in atmospheres free from SO_2. That the type of mark produced is quite different from that made on the surfaces subjected to the action of SO_2 is evident from the photomicrograph in Fig. 1. The evidence obtained seems to bear out the assumption that a dry surface will mark, whereas a surface protected with a film of adsorbed moisture, acting as a lubricating film, will not mark. While of no practical significance, as stated above, this secondary phenomenon should be borne in mind by any one studying cutlery marking in order to avoid confusion in obtaining data.

The specimens which had been subjected to the furnace atmosphere containing 1.2% SO_2 were tested chemically to determine whether or not soluble lead salts or sulphates could be detected. The specimens were treated with a solution of ammonium acetate. This solution was then made acid with acetic acid and potassium bichromate added. An orange-colored precipitate should be formed if lead is present. Similarly barium chloride should form a white precipitate if a sulphate is present. The results of the tests were negative.

(b) Second Series of Tests

While the maximum concentration of 1.2% SO_2 used in the above tests did not react to produce glaze surfaces which would metal mark it had been shown by preliminary tests, made with undetermined concentrations of SO_2, that sulphur oxide gases would react with glazes to form surfaces which could be marked. Accordingly, the second series of tests were made with 3, 5, $7\frac{1}{2}$, 10, and $12\frac{1}{2}$% SO_2. As in the first series of tests, the specimens were heated to 860°C and exposed to the action of the SO_2 gas at this temperature for one-half hour. The specimens tested represented two brands of domestic hotel ware (vitreous), one brand of English hotel ware (porous), one brand of domestic earthenware, and one brand of a domestic low-fire vitreous ware.

(c) Effect of 3% SO_2

The effect of this concentration of SO_2 was very striking when compared with the effect of 1.2%. The glaze on one brand of domestic and on the English, hotel ware was semimat; the glaze on the other brand of domestic hotel ware and on the earthenware was uniformly mat. The specimen of low-fired, vitreous ware was apparently unaffected. The glaze on the vitreous ware and the earthenware marked readily with silver, which was not surprising because the surface had been roughened considerably (see Fig. 2). The low-fired, vitreous ware would also mark with silver even though the gloss of the surface appeared unimpaired; the mark could be produced without scratching the surface and in every way resembled the condition to which the Bureau's attention had been called. When the surface was examined with the microscope, using a 16-mm. objective, numerous pits were discernible. At those points where the glaze had been marked the pits appeared as minute points of light because of the greater reflecting power of the metal with which they had been filled.

FIG. 2.—Photomicrograph (magnification 550×) of a glaze surface which became mat during exposure to SO_2 gas for 30 minutes at 860°C.

(d) Effect of 5% SO_2 The glaze on the specimen of hotel ware and earthenware was completely mat, the surface having the same appearance as that produced by sandblasting. The surfaces marked readily with silver and also with nickel and steel, although not easily. The marks could be removed easily, probably because the pits (Fig. 2) are too shallow to hold the metal. The glaze on the low-fired vitreous ware was not affected sufficiently to be detected by examination without magnification but, under the microscope, the pits appeared to be more numerous and silver would mark the surface with less applied pressure than in the case of the specimen from the preceding test.

The specimens of hotel ware and earthenware were not included in tests with higher concentrations of SO_2. It had been shown that 0.1 to 1.2% SO_2 was sufficient to produce a surface which, although of practically undiminished gloss, would scratch relatively easily while 3 and 5% SO_2 would so dull the glaze as to make a product of similar appearance unmarketable.

(e) Effect of 7½, 10, and 12½% SO_2 The glaze surfaces of the low-fired vitreous specimens subjected to these concentrations of SO_2 were visibly affected. Although the surfaces were not mat, they were dulled sufficiently to be easily differentiated from untreated surfaces. There was also a light coating of scum unevenly distributed over the specimens. The relative dullness and amount of scum increased in proportion to the concentration of SO_2. It was difficult to mark the specimens with nickel or steel, but they marked with silver very easily. The dark gray color of these marks could be removed rather easily, by washing, from the specimens exposed to 7½ and 10% SO_2, but would not wash off completely from those exposed to 12½%. It was also observed that the dulled surfaces, after washing, had a perceptible sheen or iridescence when viewed in direct sunlight and held so that the light struck the surface obliquely. Those places, however, which had been marked no longer had this sheen and consequently the surface appeared streaked and rather unsightly. Microscopic examination indicated that the thin walls of glass around the pits, or covering the bubbles just at the surface, and which in all probability caused the iridescent appearance, had been broken away by the metal.

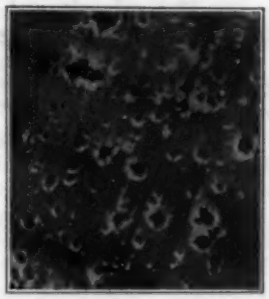

FIG. 3.—Photomicrograph (magnification 170×) of a metal mark produced with silver on a glaze surface which had been exposed to SO_2 gas for 30 minutes at 860°C. The metal mark is the lighter area in the central portion of the photograph.

Figure 3 is a photomicrograph of a surface exposed to 12½% SO_2 and

marked with silver. The mark, although dark gray in color when viewed in ordinary light, appears lighter than the adjacent glaze surface in the micrograph. The glaze surface did not appear dull when viewed by itself, but the effect of the SO_2 could be easily detected when the surface was compared directly with an untreated one. Some conception of the sizes of the pits can be obtained by comparing their diameters with the width of the mark, which was about one-fourth millimeter (or about one one-hundredth of an inch).

The mat surfaces, and a specimen of the low-fired vitreous ware which showed scumming, were treated chemically as previously described. Test for sulphate was obtained in all cases, while the scummed specimen gave a positive test for both lead and sulphate. Petrographic examination of the scum showed the presence of crystals having the optical properties of lead sulphate.

III. Summary

The results obtained are stated briefly:

(1) The glaze surface, insofar as susceptibility to metal marking is concerned, was not affected by carbon monoxide.

(2) The concentration of SO_2 gas in the furnace atmosphere as high as 1.2% did not produce a surface at 860°C on any of the specimens tested which could be metal marked.

(3) The only glaze showing harmful defects (blisters) after exposure to from 0.1 to 1.2% SO_2 was on a colored vitrified body.

(4) Increasing the concentration of SO_2 from 0.1 to 1.2% SO_2 increased the susceptibility of the surfaces to scratching with metal, particularly nickel and steel.

(5) Three per cent SO_2 in the furnace atmosphere was sufficient to so dull the glaze on two typical hotel ware and two earthenware bodies as to make them appear almost completely mat.

(6) The only specimens tested which would take a "metal mark" were of one brand of vitrified, relatively low-fired ware. Concentrations of SO_2 of 3 and 5% caused this glaze to metal mark, but produced no blistering or scumming detectable macroscopically. Concentrations of $7\frac{1}{2}$, 10, and $12\frac{1}{2}$% SO_2 produced a slight scum and impaired the gloss; evidence of marking could not be entirely removed by washing after exposure to a concentration of $12\frac{1}{2}$%; and the scum formed was composed at least partly of lead sulphate.

Acknowledgments Acknowledgment of assistance is made to G. W. Wray, who supervised the preliminary tests, and to H. Insley for the petrographic examinations and photomicrographs.

PICKLE ROOM CONTROL FOR PORCELAIN ENAMELING PLANTS[1]

By W. C. Lindemann

ABSTRACT

A procedure for pickle room control for porcelain enameling plants is outlined and "make up" for four cleaning solutions are given in detail.

I. Introduction

The uniformity of output of an enameling plant, the quality of the work, and the financial success of the plant depend largely upon the control of the various operations involved.

No doubt every enamel shop has some methods of control, since work of more or less uniformity is turned out day after day, at least for a period of time, until some epidemic of disaster strikes in the form of fishscaling, copperheads, hairlines, or some other defect.

In many shops such control as may be in use is of the "rule of thumb" nature or it is left to the man in charge to do his work to the best of his judgment or in the manner it has always been done. This might be satisfactory if there were some actual record of previous operation, but unfortunately it too often occurs that someone's memory is the only check on what actually took place.

This does not apply as a rule to smelting and milling of enamels, but it most assuredly applies to the pickling and cleaning operations. It is true that various simple tests for acid tanks, cleaning tanks, and neutralizing tanks have been developed and have been beneficial. Many enamel plants have also installed laboratories and have a chemist, which have been of tremendous value to the individual plant as well as to the industry as a whole.

With all of the aids of tests and analyses, however, there are periods of grief caused by variations in operation between the time when tests or analyses are taken, and it was to avoid trouble of this kind that the method herein described was adopted.

II. Method of Control

This method of control consists primarily of replenishing each tank daily by the amount of material that was actually used up or weakened in the solution during the day previous. The amount of material used from a tank or solution is directly proportional to the amount of steel cleaned or pickled in the solution. This factor is proportional to the surface of the steel treated and not to the weight. In other words, the loss in strength

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[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Enamel Division). Received March 14, 1931.

of a solution is directly proportional to the amount of steel in square feet that was treated in the solution.

Upon this basis, the amount of make up necessary for each tank per thousand square feet of steel treated was determined by daily analysis. After this, daily checking was carried on for several weeks, and a very definite factor was established for each tank so that the solutions could be held accurately between certain maximum and minimum strength values continuously by daily, or, in some instances, semidaily additions of material to the solution in proportion to the number of thousand square feet of steel treated in the tank.

In pickle room practice, the steel is packed in Monel metal baskets and is cleaned free from grease and oil in an electric cleaning tank. After the electric cleaning, the basket is rinsed in clean running cold water and then put in a sulphuric acid pickle. Again it is rinsed in water and then placed in a nickel solution. It is again rinsed in water and then placed in a borax solution from which it is put in a drier and is ready for the enamel coating.

The procedure is summarized in the following manner:

(1) **Electric Cleaner** Tank, 84 inches long, 36 inches wide, 30 inches working depth. Capacity at working level, 392 gallons. Solution, 125 pounds metal cleaner for new solution, or 5.1 ounces per gallon of solution. Add 6 pounds of metal cleaner per 1000 square feet of steel treated to maintain the same chemical strength. Solution should be used boiling. Strength equivalent to 1.80 to 2.50 ounces sodium hydroxide per gallon.

(2) **Acid Pickle** Tank, 72 inches long, 32 inches wide, 22 inches working depth. Capacity at working level, 220 gallons. For new solution use 120 pounds commercial sulphuric acid, 8.75 ounces per gallon of solution, and 120 pounds of Kleanrite, 8.75 ounces per gallon of solution. Add 17 pounds of acid and 6 pounds of Kleanrite per 1000 square feet of production treated. Solution should be used at a temperature of 160 to 180°F. Strength, 4 to $5^1/_2\%$ acid.

(3) **Nickel Strike** Tank, 72 inches long, 36 inches wide, 22 inches working depth. Capacity at working level 247 gallons. For new solution use $24^1/_4$ pounds of single nickel. Salts per 100 gallons of solution or 60 pounds for this tank, giving strength of approximately 0.75 ounce metallic nickel per gallon. Add $1^1/_2$ pounds of single nickel salts per 1000 square feet of metal treated. Solution to be used at 180°F. Strength is 0.65 ounce to 0.80 ounce metallic nickel per gallon.

(4) **Borax Solution** Tank, 72 inches long, 36 inches wide, 22 inches working depth. Capacity at working level, 247 gallons. New solution 1.62 ounces borax per gallon or 25 pounds borax for 247 gallons. Solution to be used hot and made up new each day.

In the above solutions for correct maintenance, any drain-out of solution should be made from a standard make-up solution.

All tanks should be checked by chemical analysis once a week.

III. Conclusion

This control method for pickle room operation has been in practical production work on full scale for about one and one-half years and the experience proves conclusively that troubles have been minimized to the greatest possible extent. It is gratifying to see the weekly analysis of the tanks and to find how closely they check in every instance.

A. J. Lindemann & Hoverson Company
Milwaukee, Wis.

PROGRESS REPORT ON DETERMINATION OF CRYSTALLINE COMPOUNDS CAUSING OPACITY IN ENAMELS BY X-RAY METHODS[1]

By A. I. Andrews, G. L. Clark, and H. W. Alexander

ABSTRACT

By use of the X-ray, the identity of the crystalline compounds present in enamels as opacifiers was determined. Tin oxide is present as SnO_2, antimony compounds as Sb_2O_4, fluorspar as CaF_2, and cryolite contributes only NaF. Other antimony compounds are not present and AlF_3 was not found in any of the enamels studied.

I. Introduction

The property of white cover enamels called opacity has received considerable attention by various investigators whose studies have been mainly in determining the factors upon which opacity depends. Although the composition of the frit, mill additions, temperature and time of smelting, temperature and time of firing, degree of fineness, and thickness of the enamel coating, are factors affecting opacity and have been studied at length, there has been but little work done to determine exactly the crystalline compounds causing the opacity in various types of enamels in which separate opacifying agents or combinations of opacifying agents are used.

(1) Statement of Problem The purpose of the investigation is to determine the crystalline compounds causing opacity in white sheet-steel cover-coat enamels and in white dry-process cast-iron enamels by X-ray methods.

The following opacifying agents are to be used separately and in suitable combinations in both types of enamels: cryolite, fluorspar, tin oxide, antimony oxide, sodium antimonate, zirconium oxide (Opax), titanium oxide, calcium phosphate (bone ash), zinc sulphide, aluminium fluoride, sodium fluoride, Meltopax (a sodium aluminium zirconium silicate), sodium silico-fluoride, and zircon.

(2) Review of Literature A review of the literature reveals but little exact information upon the subject, although various writers have given theories concerning the cause of opacity in enamels and glasses and some investigators have made X-ray determina-

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[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Enamel Division). Received June 9, 1931.

This paper is a Progress Report upon a problem being investigated as partial fulfilment of requirements for a Master's Degree in Ceramic Engineering at the University of Illinois. The results and conclusions given are based upon information obtained to date and are subject to revision in the final report. It is a coöperative problem between the Ceramic and Chemistry Departments.

tions of opacifying compounds in glasses. Agde, Krause, and Lehmann[2] concluded that with the use of NaF as the opacifying agent, NaF separated from the cooling solvent and produced turbidity; when AlF_3 was used NaF was formed; with CaF_2, the opacity was due to CaF_2 and NaF. Enequist[3] claimed that the opal color was due to SiF_4. Zschimmer[4] stated that the turbidity of opaque glass was the result of the precipitation of minute spheroids of F compounds, principally NaF and CaF_2. Otremba[5] stated that the opacity was due to crystals when cryolite was used and to fine air holes when fluorspar was employed. Bock[6] claimed that fluorine had no influence whatever on the opacity of the resulting enamel. Ryde and Yates[7] found that the opacity of opal glasses has been attributed to Al_2O_3, Al_2F_6, Na_2SiF_6, SiO_2, SiF_4, and aluminium silicates; their results, however, showed that the opacity of fluorine glasses was due either to NaF or CaF_2 or both. Other writers and investigators have stated that opacity was due to AlF_3, SiO_2, B_2O_3, clay, and oxides of Sn, Sb, Ti, Zr, when compounds of these metals were used in the enamel; feldspar, colloidal silica or alumina, and to occluded gases. In all the literature reviewed, however, there was very little well-founded information regarding the cause of opacity in enamels and little or no work has been done to determine the opacifying compounds present in typical enamels when known opacifying agents are used.

II. Study Procedure

Typical enamel frits were compounded with the desired opacifying

[2] (*a*) G. Agde and H. F. Krause, "The Study of the Behavior of Fluoride Additions to Glasses and Enamels," *Z. angew. Chem.*, **40,** 525–33 (1927); *Chem. Abs.*, **21,** 2966 (1927); *Chem. & Ind.*, **46B,** 483 (1927); *Ceram. Abs.*, **6,** 374 (1927); Amer. Ceram. Soc., Enamel Bibliography, p. 1. (*b*) G. Agde, H. F. Krause, and W. M. Lehmann, "Behavior of Fluorides in Glasses and Enamels," *Z. angew. Chem.*, **40,** 804 (1927); *Chem. & Ind.*, **46B,** 654 (1927); Amer. Ceram. Soc., Enamel Bibliography, p. 3. (*c*) G. Agde and H. F. Krause, "The Effect of Fluoride Additions to Glasses and Enamels. The Causes of Fluorine Losses during Smelting of Glasses and Enamels with Fluoride Additions," *Z. angew. Chem.*, **40,** 886–95 (1927); *Chem. & Ind.*, **46B,** 702 (1927); *Chem. Abs.*, **21,** 3434 (1927); Amer. Ceram. Soc., Enamel Bibliography, p. 1.

[3] E. Enequist, "Chemistry of Opaque Glass and Enamel," *Chem. Eng.*, **10,** 54 (1909); *Chem. Abs.*, **3,** 2865 (1909); Amer. Ceram. Soc., Enamel Bibliography, p. 110.

[4] E. Zschimmer, "Fluor-Opal and Theory of Opaque Glass Used in the Illuminating Industry," *Sprechsaal*, pp. 347–49, 364–66 (1930); *Chem. Abs.*, **24,** 3617 (1930).

[5] A. Otremba, "Fluorine in Enamel Melting," *Keram. Rund.*, **34,** 158–60 (1926); *Ceram. Abs.*, **5,** 299 (1926); *Chem. Abs.*, **20,** 3339 (1926); Amer. Ceram. Soc., Enamel Bibliography, p. 231.

[6] B. Bock, "Importance of Fluorine in Enamels," *Chem.-Ztg.*, **32,** 730–32 (Aug. 1); *Chem. & Ind.*, **27,** 900 (1908); *Chem. Abs.*, **2,** 2718 (1908); Amer. Ceram. Soc., Enamel Bibliography, p. 29.

[7] J. W. Ryde and D. E. Yates, "Opal Glasses," *Jour. Soc. Glass Tech.*, **10T,** 274–94 (1926).

TABLE I

COMPOSITION OF ENAMEL FRITS

	49Sb	50Sb	R52	49NA	50NA	48NA	49Sn	50Sn	R42	R46	5B	50NSF	49NSF	48Sb	48Sn	A	Def
Feldspar	32.1	32.1	33.1	32.1	32.1	32.1	32.1	32.1	33.4	38.0	28	32.1	32.1	32.1	32.1	28	28
Borax	24.7	24.7	28.2	24.7	24.7	24.7	24.7	24.7	19.5	21.5	28	24.7	24.7	24.7	24.7	28	28
Flint											18					18	18
Na ash	3.7	3.7	5.65	3.7	3.7	3.7	3.7	3.7		3.0	9	3.7	3.7	3.7	3.7	9	9
$NaNO_3$	2.9	2.9		2.9	2.9	2.9	2.9	2.9	2.45	3.0	5	2.9	2.9	2.9	2.9	5	5
Whiting	2.5	2.5	2.42	2.5	2.5	2.5	2.5	2.5				2.5	2.5	2.5	2.5		
ZnO	11.6	11.6	11.3	11.6	11.6	11.6	11.6	11.6	10.2	10.5		11.6	11.6	11.6	11.6		
$BaCO_3$	6.6	6.6	6.45	6.6	6.6	4.6	6.6	6.6		5.0		6.6	6.6	4.6	4.6		
Red lead										16.8							
Boric acid									17.9								
Fluorspar	6.0		4.83	6.0		4.0	6.0			5.0			6.0	4.0	4.0	12	4.5
Cryolite		6.0	3.22		6.0	4.0		6.0	9.8	3.0	12	6.0		4.0	4.0		7.5
Sb_2O_3	9.9	9.9	4.83											9.9			
Na antimonate				9.9	9.9	9.9											
SnO_2							9.9	9.9	6.75	9.0					9.9		
Na_2SiF_6												9.9	9.9				

agent or agents present. (The compositions of the enamel frits used are given in Table I.) The frit batches were fused in crucibles in gas-fired smelting pots and threads taken from the fused enamel and used as test specimens for the X-ray examination. The remainder of the frit was quenched in water, dried, and ground for application to test pieces of cast iron and sheet steel of suitable size and shape to be examined with the X-ray. The pattern obtained by the Hull-Debye-Scherrer powder method[8] for the enamel was compared with patterns for pure compounds to determine the compound or compounds causing opacity. The monochromatic pinhole method also was used in cases where the Hull-Debye-Scherrer powder method was unsuitable.

Both methods may be carried on at the same time on the General Electric multiple diffraction apparatus.

(1) The X-Ray Examinations Crystalline compounds each have definite form and size of unit crystal which are characteristic. X-rays are diffracted by crystalline compounds and if a photographic plate or film is so placed that the compound is between the plate or film and the X-ray source, a pattern is obtained on the plate or film (due to the diffracted rays), that

[8] G. L. Clark, X-Ray Metallography of 1929. G. L. Clark, Applied X-Rays. Terrill and Ulrey, X-Ray Technology.

is characteristic of the compound. Patterns thus obtained can be measured and with the proper calculations the size and kind of the unit crystal can be obtained and this identified.

As the substances causing opacity are believed to be crystalline compounds their identity can be established by X-ray examinations and subsequent calculations. It is much simpler, however, to compare the pattern

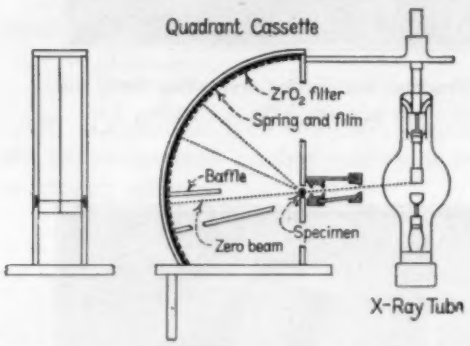

FIG. 1.—Powder diffraction apparatus of General Electric Company.

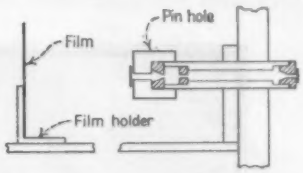

FIG. 2.—Apparatus for pinhole diffraction pattern

of the enamel with the pattern of pure compounds and thus to identify the opacifying compound or compounds. (For example see Figs. 3 to 7.)

III. Discussion of Results

(A) Crystalline Sb_2O_5 (antimony pentoxide) is the compound causing opacity in enamels containing the following opacifying agents:

(1)	Antimony oxide and fluorspar	Enamel 49Sb
(2)	Antimony oxide and cryolite	Enamel 50Sb
(3)	Antimony oxide, fluorspar, and cryolite	Enamel R52, 48Sb
(4)	Sodium antimonate and fluorspar	Enamel 49NA
(5)	Sodium antimonate and cryolite	Enamel 50NA
(6)	Sodium antimonate, fluorspar, and cryolite	Enamel 48NA

(B) Crystalline SnO_2 (tin oxide) is the compound causing opacity in enamels containing the following opacifying agents:

(1)	Tin oxide and fluorspar	Enamel 49Sn
(2)	Tin oxide and cryolite	Enamel 50Sn, R42
(3)	Tin oxide, fluorspar, and cryolite	Enamel 48Sn, R46

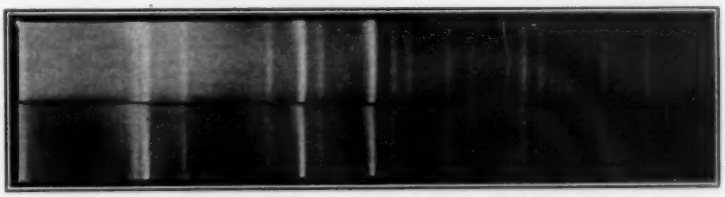

FIG. 3.—Hull-Debye-Scherrer diffraction pattern for crystalline Sb_2O_5, antimony pentoxide. Pattern obtained for antimony enamels, 49Sb, 50Sb, R52, 48Sb, 49NA, 50NA, 49NA.

FIG. 4.—Hull-Debye-Scherrer diffraction pattern for crystalline SnO_2, tin oxide. Pattern obtained for tin enamels, 49Sn, 50Sn, R42, 48Sn, R46.

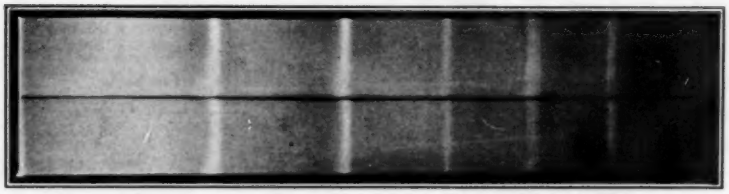

FIG. 5.—Hull-Debye-Scherrer diffraction pattern for crystalline NaF, sodium fluoride. Pattern obtained for cryolite enamels, B, 50NSF.

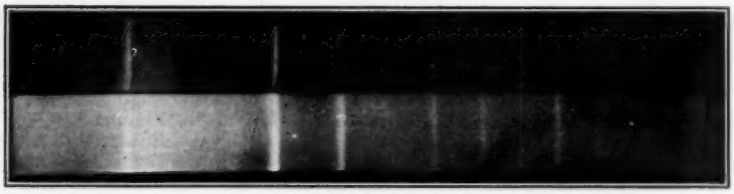

FIG. 6.—Hull-Debye-Scherrer diffraction pattern for crystalline CaF_2, calcium fluoride, or fluorspar. Pattern obtained for fluorspar enamels, A, 49NSF.

FIG. 7.—Hull-Debye-Scherrer diffraction pattern for crystalline NaF plus CaF_2, sodium fluoride plus calcium fluoride. Pattern obtained for cryolite plus fluorspar enamels, Dcf, 49NSF, 48NSF.

(C) Crystalline NaF (sodium fluoride) is the compound causing opacity in enamels containing the following opacifying agents:

(1) Cryolite	Enamel B
(2) Cryolite and sodium silico-fluoride	Enamel 50SNF

(D) Crystalline CaF_2 (calcium fluoride) is the compound causing opacity in enamels containing the following opacifying agents:

(1) Fluorspar	Enamel A
(2) Fluorspar and sodium silico-fluoride	Enamel 49SNF

(E) Crystalline NaF and CaF_2 (sodium fluoride and calcium fluoride) are the compounds causing opacity in enamels containing the following opacifying agents:

(1) Cryolite and fluorspar	Enamel Dcf

IV. Summary

(1) SnO_2 is the primary opacifying compound when commercial tin oxide is the primary opacifying agent.

(2) Sb_2O_5 is the primary opacifying compound when commercial antimony oxide or sodium antimonate are the primary opacifying agents.

(3) Sodium silico-fluoride, fluorspar, and cryolite aid in the development of opacity when used with tin oxide, antimony oxide, or sodium antimonate, but do not in themselves cause opacity.

(4) Commercial antimony oxide is oxidized during smelting to antimony pentoxide.

(5) The tin oxide which causes the opacity is not dissolved by the smelting.

(6) Sodium silico-fluoride, fluorspar, or cryolite give opaque glass when used as opacifying agents alone.

(7) Sodium antimonate reacts with the enamel glass leaving crystalline antimony pentoxide as an insoluble opacifying agent.

(8) The other known opacifying agents: Opax (zirconium oxide), Meltopax (a sodium-zirconium-silicate), titanium oxide, bone ash (calcium phosphate), zircon (zirconium silicate), and others mentioned before are being studied alone and in combination and will be reported on later.

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ADDITIONAL DATA ON STOKER-FIRED TUNNEL KILN[1]

By G. G. Kent and E. M. Rupp

ABSTRACT

A description is given of the stokers, their operation, the difficulties that were overcome in order to adapt them successfully to this type of work, and the method of handling the fuel from hopper cars to the kiln. The economies effected by the installation and the subsequent changes in methods of handling the product are also given.

I. Introduction

The first application of stoker firing to a tunnel kiln was made at the Peru, Indiana plant of the Square D Company, where dry-pressed electrical porcelain is manufactured.[2] The first stokers possessed some weaknesses and the new ones were developed by the Laclede Stoker Company.

II. Stokers

The new set of stokers was installed early in 1930 and are of the same type as the original set, incorporating improvements brought about by experience with the original stokers.

There were some mechanical weaknesses in the original stokers which were eliminated by heavier construction in the new set.

The original tuyères were of gray iron, but tuyères of special alloy steel were in use for 17 months and were still usable when removed. Tuyères of this special alloy were installed with the second set of stokers and showed no indication of failure after nearly a year's operation.

With the positive air control incorporated in the new design, no trouble has been experienced in maintaining the proper condition in each furnace separately and in regulating exactly as desired the length of flame which passes into the tunnel where combustion is completed.

In the first installation, cleaning the furnaces was a most serious difficulty due to clinkers freezing to the side and back walls, which were of clay refractories. In installing the new stokers the firebrick side and back walls were removed to a height of four courses above the grates and replaced with silicon-carbide brick which are air-cooled. This air enters one side of the furnace, passes back of the bridge wall, and out on the opposite side. This plan has eliminated the cleaning difficulties and it is now possible to clean a furnace thoroughly in less than five minutes with such a small drop in furnace temperature that the crown couples in the tunnel are not affected. Each furnace is cleaned once every 24-hour period and the cleaning

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[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (White Wares Division). Received February 12, 1931.

[2] C. B. Harrop and H. S. Orth, "Stoker Application to the Car Tunnel Kiln," *Jour. Amer. Ceram. Soc.*, **12** [6], 406–409 (1929).

has been so arranged that no car is directly subjected to the cleaning influence more than once.

With the original design there was a tendency for the stoker frames to burn up and warp, thus allowing considerable air leakage. Accordingly, the frames of the new stokers are cored for air cooling, the air being obtained from the main air supply fan. The frames seal against a recess in the brickwork, making the front of the stoker flush with the furnace front. The furnace doors are lined with a rammed or monolithic lining and both these doors and the ash-pit doors are machined so as to allow a minimum of air leakage.

All of the air for the kiln is furnished by one air-supply fan driven by a 10 h.p. motor.

FIG. 1.

III. Economies Effected

At the time the tunnel kiln was being considered a battery of five periodic kilns was in use. These were in a straight line and a conveyer was used for loading and unloading. This gave an efficient operation with a minimum of labor for this type of kiln. Accordingly, the savings in labor on changing from periodic to tunnel kiln operation were less than could be expected in most installations.

It was necessary, therefore, to effect sufficient savings elsewhere to justify the investment required by a tunnel kiln and a building to house it. Natural gas was not available, manufactured gas was prohibitive, and the increased cost of fuel oil in a tunnel kiln was sufficient so that the net economy did not justify the investment. The use of coal was indicated and has been justified in this installation.

In the periodic kilns a good grade of Kentucky coal (5 by 2) was used. With the tunnel kiln, the 2-inch modified slack grade of the same Kentucky coal is being used. It was found by experimenting with several grades of gas coal that the best results are to be obtained with a coal having the following analysis:

Moisture	1.80%	Sulphur	0.60%
Volatile	36.00%	B.t.u.	14,415
Fixed carbon	59.25%	Fusion temperature of ash	2450°F
Ash	4.75%		

Considering the difference in cost of the two grades of coal, as well as the increased capacity obtained in the tunnel kiln, there is a fuel savings of approximately 70%.

The building which houses the kiln is 300 by 88 feet, has two saw-tooth bays and one monitor bay, and is heated by the waste heat from the kiln. This building also houses the cleaning, glazing, inspection, and shipping departments.

The installation of the tunnel kiln led to the design of a conveyer which is used for handling ware through cleaning, glazing, and placing. The car loading is done at the end of this conveyer. In the unloading and inspection departments a similar conveyer of the carrousel type was also installed. This effected some savings in handling the finished ware and empty saggers.

The improved quality generally expected with a tunnel kiln has been realized, including more uniform firing, reduction of the number of rejects due to handling, overfiring, and underfiring, and a more uniform finish on glazed pieces.

IV. Conclusions

A year's experience with the improved type of stoker has clearly demonstrated that this installation is quite satisfactory from the standpoint of manufacturing economies and improved quality of the product. This method is worthy of consideration by those who have neither gas nor fuel oil available at such a price as to be competitive with coal.

The Square D Company
Peru, Indiana

OBSERVATIONS ON THE FIRING OF A DOWNDRAFT KILN WITH A STOKER SITUATED OUTSIDE THEREOF[1]

By W. E. Rice[2] and H. C. Harrison[3]

ABSTRACT

This paper presents some observations that were made during a series of tests on round downdraft kilns fired with a single stoker, and shows the economies that can be expected with this method of firing and the disadvantages that must be overcome.

I. Purpose of Investigation

During 1930, the U. S. Bureau of Mines in coöperation with The Ohio State University Engineering Experiment Station, made seven tests on kilns fired with a stoker in a small furnace situated outside and adjacent to them.

The purpose of these tests was as follows: (1) to determine the characteristics of operation that such an installation must possess to enable it to fulfil the conditions imposed by the kiln and ware and (2) to develop the plant to a degree of perfection to make it a reliable and controllable source of hot gases for the kiln, so that design of kilns and settings could be studied independently of the variables introduced by hand firing.

II. Description of Stoker and First Installation

(1) Stoker The stoker is of the small overfeed type developed for small industrial furnaces and boilers up to 250 horse power. It consists of a series of five step-grates, of which the first and third are given a reciprocating forward and backward movement by a $^1/_2$-h.p. motor; the second, fourth, and fifth grates are stationary. The reciprocating movement feeds the coal from the hopper and advances the fuel bed; it can be adjusted by means of a link between zero and 4 inches per stroke, which corresponds to a change of rate of movement of the fuel bed from zero to 320 feet per hour. An adjustable gate regulates the depth of the fuel bed between $3^1/_2$ and 7 inches. Thus, the rate of feeding coal is variable within wide limits.

The rate of burning depends on the supply of air, rate of admission of which is controlled by a damper between the fan and the wind-box under the grates. A damper in the wind-box permits control of the relative amounts

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of air supplied under the front and rear halves of the grate. At first the fan was driven by a 5-h.p. motor, but later by one of $7\frac{1}{2}$ h.p.

The grate is 6 by 7 feet, or 42 square feet in area. The kilns fired are round, 32 feet inside diameter (the area inclosed by their walls is 804 square feet) hence, the area of the grates is 5.2% of the area inclosed by the walls of the kilns. This compares to 12.5% generally recommended for hand-fired kilns in which the coal is burned by natural draft. The stoker

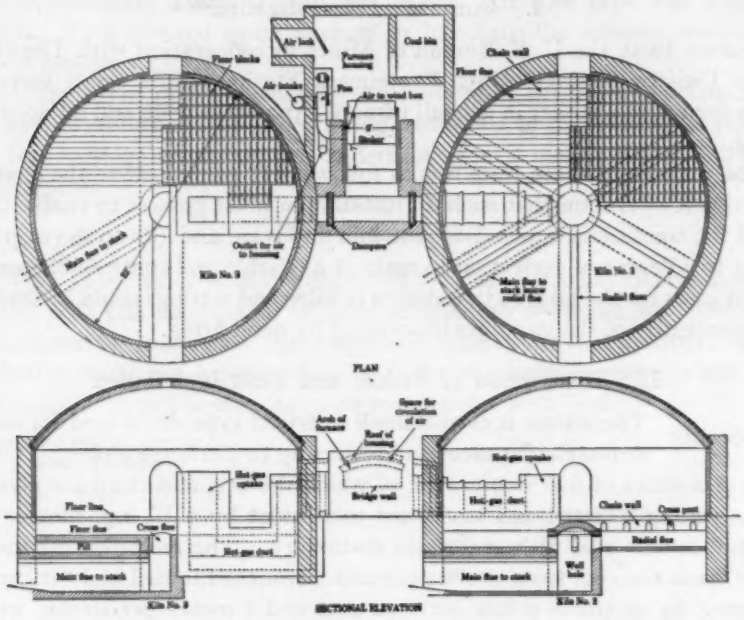

FIG. 1.—Plan and sectional elevation of first setting of stoker to fire two kilns alternately.

is rated by the manufacturers to burn 1500 pounds of coal an hour, or approximately 35 pounds per square foot per hour.

Two different installations were tried, in both of which the furnace was inclosed by a housing where a pressure of air greater than that in the furnace could be developed and maintained by means of a by-pass from the forced-draft fan. This construction makes it possible to maintain pressures in the furnace and kiln, but avoids the damage that would otherwise be caused to refractories in the furnace by outward leakage of hot gases.

(2) Kilns Figure 1 is a plan of the first installation. This was designed to fire two kilns alternately with one stoker and furnace placed between them.

As shown in Fig. 2, the furnace was above the floor level of the kilns and

the hot-gas duct into the kiln designated "No. 2" was made of 36-inch fireclay sewer pipe laid in a cradle of fire brick on the floor of the kiln. The hot-gas duct into kiln 3 was under the floor from the wall to near the center of the kiln. The stacks at the ends of the hot-gas ducts that carried the gases upward in the kilns were approximately $4\frac{1}{2}$ feet high. Figure 3 is a section through the stoker, furnace, and housing.

III. Tests with First Installation

Three trials were made with the first installation; the first on kiln 3, the second on kiln 2, and the third on kiln 3. Inasmuch as neither of the kilns had been used before their first trials with the stoker, they were heated slowly to avoid damage by unequal expansion which might result from too

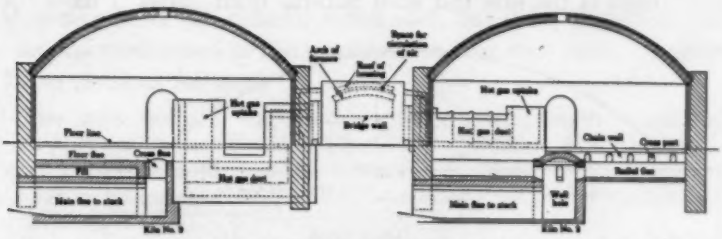

FIG. 2.—Sectional elevation of first setting of stoker to fire two kilns alternately.

rapid heating. The first trial was made with a firing schedule of 20 days, the second, 14 days, and the third, 7 days.

(1) Increased Kiln Capacities For the first test, kiln 3 was set with 76,380 face brick, for the second test, kiln 2 with 78,660 face brick, and for the third test, kiln 3 with 74,005 face brick. The capacity of these 32-foot kilns as normally set at the plant is 70,300 brick; therefore, the capacity gained by elimination of the 12 bag walls around the kiln was 8.7%, 11.9%, and 5.3%, respectively, in these three tests. In none of these was the setting as close to the walls as it should have been.

(2) Coal Consumption The coal used for the first two trials was 183 and 92 tons, respectively; these amounts were high principally because of the slow schedules of heating, hence, these figures are not of interest. The third trial was fired with 53 tons of coal, or 1432 pounds per 1000 brick. The kiln was fired in $161\frac{1}{2}$ hours, but should have had about 12 hours more time to soak. The average practice at the plant at this time was 1733 pounds of coal per 1000 brick, and 240 to 260 hours to fire; hence, the saving with the stoker was 17.3% of the weight of coal used and 30% of the time required.

The coal burned was slack from the Middle Kittanning (No. 6) coal bed, Crooksville field, Ohio. Its calorific value was 11,590 B.t.u. per pound and the softening temperature of its ash was 2230°F. This slack cost $1.10 per ton delivered, whereas for hand firing, the run-of-mine coal from the same mine cost $1.60; the saving in cost of coal, therefore, for the third test was 43%.

In the first installation the furnace had three water-cooled elements, one at the slag line in each side wall and a pipe to support the rear end of the grates, as shown in Fig. 3. During the first three trials a reliable supply of water for these parts was not available and they were frequently endangered by interruptions to the supply.

(3) Test No. 1 on Kiln 3 The prearranged schedule of a slow rate of heating was followed without difficulty during the first 5 days of the first test with natural draft; after 5 days the fan

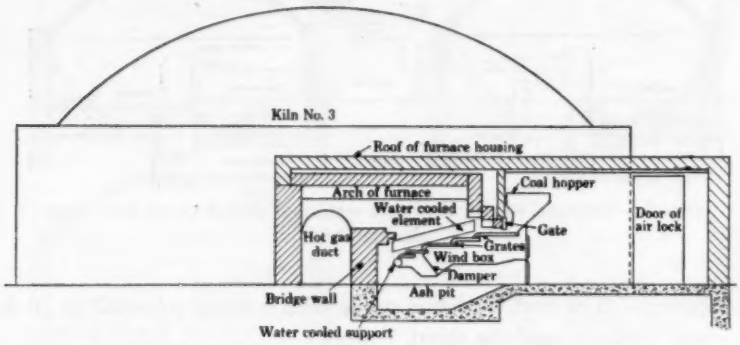

FIG. 3.—Section through stoker and furnace in first setting.

was started and forced draft used. The schedule was followed easily until the temperature in the top of the kiln reached 1700°, after which the temperature in the kiln could not be increased because of a large drop in temperature of the gases between the furnace and the kiln. Apparently, this was caused by inability to burn enough coal, slow movement of the gases in the duct, and the resistance offered by four right-angle bends in the path of the gases; therefore, this test was stopped.

(4) Test No. 2 on Kiln 2 In this test the prearranged schedule was followed until the temperature in the top of the kiln reached 1700°F, after which the temperature could be increased only slowly and with difficulty, accompanied by excessively high temperatures at places in the furnace where holes burned through the fuel bed. A temperature of 1950°F was attained in the top of the kiln, but it was necessary to stop the test before the firing could be completed because the arch in the front of the furnace slagged so badly that a section of it fell in.

(5) Test No. 3 on Kiln 3 The furnace was repaired, the area of the duct into kiln 3 was reduced to increase the velocity of gases through it, and the third test was started. This was on a faster schedule than the preceding tests. The schedule was followed until the top reached 1950°, when again it could not be maintained because of inability to burn the coal fast enough; even with the rate of burning attained, excessive temperatures at the rear end of the furnace caused the arch to burn and fall in, so that this test also was stopped without completing the firing. This, however, was a more satisfactory test than the other two.

IV. Discussion of Three Tests

An arrangement that will permit one stoker to serve two or more kilns is desirable because of the reduced initial cost, but these three tests showed some serious weaknesses in the construction that was used, the principal ones being given as follows:

(1) The large housing was a cumbersome arrangement which did not serve its purpose in that it did not facilitate operation of the stoker; also, the correct difference of pressure between the furnace and housing could not always be maintained because of the necessity of removing ash through the small air-lock.

(2) The dampers between the furnace and kilns were a source of trouble, and indicated that they would be so continually because of the high temperatures to which they were subjected.

(3) The strut-like part of the housing between the two kilns developed troublesome cracks because of the expansion of the kilns.

(4) Although it would have been possible to have developed enough heat to complete the firing by increasing the speed of the forced-draft fan, the loss of heat in the long passages from the furnace to the kilns was so great that it would have required extremely high temperatures in the furnace accompanied by severe erosion by slag. The latter trouble would have been less in evidence if a coal with more refractory ash could have been used.

Instead of attempting to overcome these difficulties in the original installation, it was decided to construct an entirely new installation which would eliminate their causes, as it was believed that this procedure would hasten progress of the investigation.

V. Description of Second Installation

The second installation, shown in Fig. 4, is arranged for the firing of only one kiln. The furnace is built with its rear end toward the kiln, in a pit whose floor is $7\frac{1}{2}$ feet below the floor of the kiln. The entire space under the grates forms the wind-box and the ash is discharged into a deep pit at the rear, whence it is removed through a door at the side. The rear end of the grate is supported by a wall that also serves to separate the wind-box

from the ash-pit, and silicon-carbide refractories are used in each side wall at the slag line instead of the water-cooled elements of the first installation, so that there is no water-cooled part in the second setting. A flat suspended arch is used instead of the sprung arches of the first furnace. The

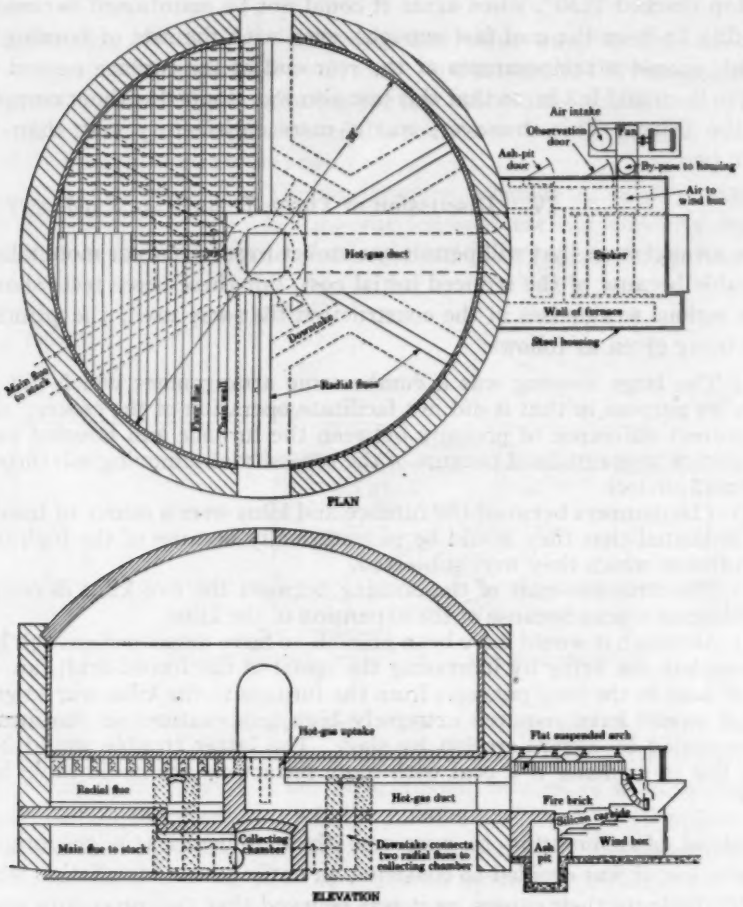

FIG. 4.—Second setting of stoker to fire one kiln.

whole furnace is inclosed in a steel housing which is only a few inches larger than the furnace.

From the rear of the furnace at the wall of the kiln a hot-gas duct 3 feet wide by 27 inches high at the walls with a 12-inch rise in its arch leads to an uptake at the center of the kiln. The bottom of this duct is $4\frac{1}{2}$ feet below the floor of the kiln and the top is at the level of the suspended arch of the furnace. The permanent uptake at the center of the kiln ends at the floor, so that a temporary track can be laid across it for entrance of cars of dried

brick for setting; when the kiln has been set to the center the uptake is extended by 9-inch walls of fire brick to about 5 feet above the floor. These brick are laid without mortar to facilitate their removal for subsequent settings.

VI. Tests with Second Installation

Four firing trials were made with the second installation, and their results are summarized in Table I.

TABLE I

TESTS ON KILNS FIRED WITH STOKER IN SECOND INSTALLATION

Item	Test 4	5	6	7
Brick in kiln	57,919	64,697	93,260	94,848
Type of brick	3-in. Dunn lug pavers	3-in. Dunn lug pavers	Face	Face
Firing period (days)	$6^1/_4$	7	$5^1/_4$	$10^3/_4$
Coal burned (tons)	49.3	49.9	40.6	92.2
Coal per 1000 brick (lb.)	1704	1541	871	1943
Increased setting (%)	13.5	26.8	32.7	35.0
Coal, weight saved (%)	41.1	46.7	49.7	−12.1
Coal, cost saved (%)	59.5	63.4	65.4	22.9

In normal operation of the hand-fired kilns at this plant a 32-foot kiln is set with 51,000, three-inch Dunn lug pavers and the consumption of coal is 2890 pounds per 1000 brick. This consumption of coal is higher than good practice; therefore, if instead of the average coal used at this plant, 2000 pounds per 1000 pavers are taken as a fair figure, the coal saved is 14.8% and 23.0% and the saving in cost of coal is 41.4% and 47.0% for tests 4 and 5, respectively. The saving of fuel in these trials is due to three factors: (1) increased setting in the kiln to absorb heat, (2) improved control afforded by forced draft, and (3) faster rate of firing. The use of lower priced coal on the stoker than can be burned in hand-fired furnaces accounts for a greater saving in cost than in quantity of fuel.

In tests 4, 5, and 6, prearranged schedules of heating were followed to completion. For test 7, the kiln was set without the extension of the hot-gas uptake above the floor, so that hot gases were exposed to the ware as soon as they passed above the floor. This was done to try to heat the lower part of the setting faster and to eliminate the lag of temperature between the top and bottom. The result was that twice the hot-gas uptake was filled with brick which fell from the setting and the test had to be stopped each time to clear it; the second time the uptake was extended to 5 feet above the floor, after which the firing was completed. Therefore, the unsatisfactory results of this test cannot be charged against the stoker.

VII. Discussion of Two Sets of Tests

(1) Heat Accounts The heat account of the furnace and kiln affords another means of comparison of these results with

average practice. Table II gives a complete heat account of a kiln that may be called representative of good hand-firing practice and one for test 6, in which no attempt was made to measure the heat stored in the kiln and other small losses.

TABLE II

HEAT ACCOUNTS, IN PERCENTAGE OF TOTAL HEAT IN FUEL FIRED

Heat item	Hand-fired kiln	Stoker-fired kiln, test 6
Used to fire ware	26.3	49.5
In combustible in ash	4.4	1.5
In combustible in flue gases	0.3	0.1
In dry flue gases	31.8	23.2
In water vapor in flue gases	6.2	5.0
Used to evaporate moisture from brick	0.9	
Stored in walls of kiln	6.3	
Stored in crown of kiln	2.1	
Lost by radiation from walls of kiln	1.3	20.7
Lost by radiation from crown of kiln	5.0	
Stored in bottom of kiln	10.9	
Not accounted for	4.5	
Total	100.0	100.0

Comparison of these heat accounts shows that the saving of coal is accomplished principally by the absorption of more heat by the setting and the decreased loss of heat in dry flue gases.

Another item that is materially decreased by the stoker is the heat lost in combustible in the ash and refuse removed from the ash-pit. With regard to the loss of combustible in ash it is of interest to note that whereas analysis of ash showed 25% combustible for the first test with the stoker, this was progressively reduced as the fireman became more familiar with the operation of the stoker, until it was only 7% for test 7. The 1.5% of heat lost in combustible in the ash in test 6 corresponds to about 10% by weight combustible in ash and refuse.

(2) Pressures Maintained in System

The outstanding features of these installations are (1) the method of introducing hot gases at the center of the kiln and (2) the inclosure of the furnace in a pressure chamber, thereby providing means to maintain pressures throughout the system. Table III gives the average pressures in the wind-box, furnace, housing, and kiln during test 6 in inches of water column. These are representative of the performance of the second installation. With them is given the power required by the motor that drives the forced-draft fan, in kilowatts per 24-hour day. No pressures were measured in the furnace in the first 35 hours because during that time forced draft was not used. The pressures given are averages of hourly observations made during the intervals indicated in the first column. Temperatures measured in the kiln show that the

TABLE III

PRESSURES IN FURNACE AND KILN DURING TEST 6

Time (hours)	Pressures (inch of water)							Power to drive forced-draft fan (kw./day)
	Wind-box	Furnace	Furnace housing	Kiln				
				Top	Middle	Bottom	Main flue	
0–35				−0.013	−0.068	−0.084	−0.236	56.3
35–47	+0.379	+0.039	+0.114	+0.116	+0.039	+0.005	−0.159	88.0
47–80	+0.963	+0.343	+0.420	+0.364	+0.276	+0.233	−0.108	140.0
80–126	+1.242	+0.512	+0.580	+0.464	+0.398	+0.359	−0.132	133.0

\+ indicates pressure greater than atmospheric.
− indicates pressure less than atmospheric.

firing of a kiln under pressure does not improve the distribution of heat from top to bottom of the setting materially, although the outside of the setting may be slightly hotter because infiltration of cold air is avoided. This method of operation did not result in any damage to the kiln.

(3) Rates of Burning In the first installation, the highest rate of burning maintained was 1039 pounds of coal an hour, or 25 pounds per square foot of grate per hour. In the second installation, higher rates could be maintained when desired; for example, during a 6-hour period of test 7, coal was burned at the rate of 1668 pounds per hour, or nearly 40 pounds per square foot of grate per hour, which is in excess of the rated capacity of the stoker. These high rates, however, are probably not desirable or necessary; if test 6 be taken as representative, a rate of 900 pounds per hour was apparently ample, for during this test the average rates were 350 pounds per hour during the first 35 hours, 538 pounds from the 35th to the 47th hour, 700 pounds from the 47th to the 80th hour, and 852 pounds from the 80th to the 126th hour.

The power required to drive the stoker did not seem to vary materially with the rate of burning, but it was sometimes slightly increased by clinkers on the grates. The power required by the $^1/_2$-h.p. motor which drives the stoker is 2.83 kilowatts per 24-hour day.

In the second installation there was some leakage from the wind-box to the rear of the furnace; also, the walls of the furnace pulled away from the kiln and opened cracks through which air from the housing leaked into the hot-gas duct. Therefore, at no time was it possible to reduce the excess air as low as it should have been. In test 6 the lowest percentage of excess air was 78, the average condition during the last 46 hours of the test, when 20% would have been more desirable.

(4) Operation of Stoker Operation of the stoker to date has required more attention than is desirable. To adhere to a fixed schedule of heating requires frequent adjustment of the rate of feeding coal and of the dampers which control the amount of air admitted and also the pressures. Further, to remove ash from the ash-pit it is necessary to reduce the pressure in the furnace by stopping the forced-

draft fan; to slice the fire and keep it free of clinkers it is necessary to empty the coal hopper, stop the fan, and insert the slice bar under the coal gate. These operations all require time and labor, and the interruptions make an irregular rate of heating and prevent the constant operation which is desirable for a thorough study of the kiln and setting. These are details that are of more importance in this particular type of stoker application than they would be in others, especially if the furnace were not operated under pressure.

(5) Maintenance During the seven tests there was no deterioration of the parts of the stoker, save that twice when the

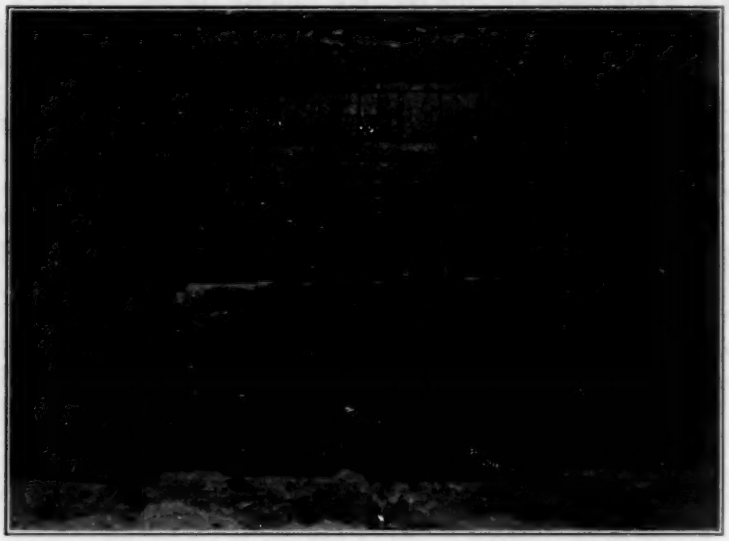

FIG. 5.—Interior of furnace after 526 hours of service, showing deterioration of refractories.

pressure in the furnace was high the coal ran so low in the hopper that it did not form an effective seal against the gases, so that the fire burned back into the hopper and burned the coal gate, necessitating replacement.

The low fusion temperature of the coal ash caused severe erosion and corrosion of the refractory walls and arch of the furnace. It did not damage the hot-gas duct noticeably, but much ash was carried into the kiln where it deposited in the form of fine dust $^1/_2$ to $^3/_4$ inch thick on all exposed parts of the setting; this did not damage the kiln or the ware, but conceivably it might damage some ware. Some ash adhered to the crown where droplets melted and dropped onto the top courses of the setting, but these did not adhere to the brick and caused no damage. The accumulation of ash, however, is detrimental when the kiln is drawn,

FIG. 6.—Interior of furnace after 700 hours of service, showing further deterioration of refractories (taken from same point as Fig. 5).

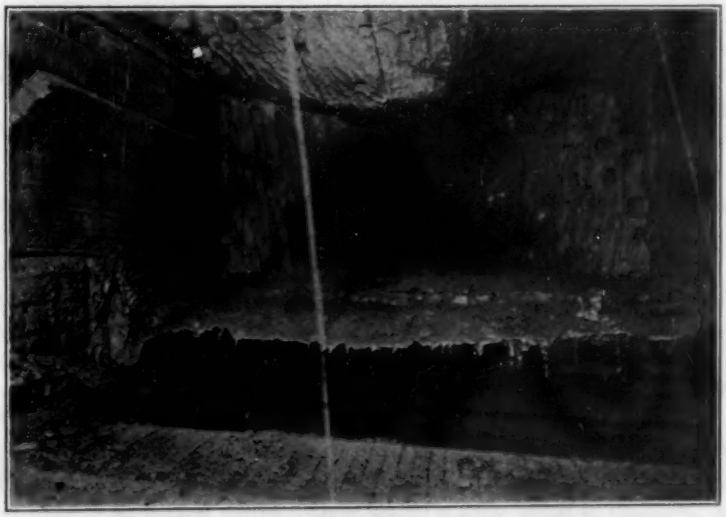

FIG. 7.—Rear part of furnace and hot-gas duct after 700 hours of service.

as most of it finds its way into the flues which, as a result, must be cleaned frequently.

The erosion of refractories in the furnace is more serious. Figure 5 is a photograph of the interior of the furnace after 526 hours of service and Fig. 6 is another photograph taken from the same place after 174 additional hours of service, or a total of 700 hours. These show deep channels in the arch near each side wall and failure of side walls.

Apparently, failure of the arch was due in part at least to poor distribution of air under the grates. The failure of the side walls was due partly because they were not well enough tied to the outer wall, but Fig. 6 shows that some of the brick were eroded nearly half through. These two figures also show that the silicon carbide at the slag line did not deteriorate noticeably. Figure 7 is a view looking from the front toward the rear of the furnace and into the hot-gas duct; it also was taken after 700 hours of service. It was necessary to replace parts of the side walls after 700 hours, and to replace the arch after less than 900 hours of service. Seven hundred hours is equivalent to four 7-day firings.

VIII. Summary

This application of a single stoker to a round downdraft kiln included the three ideal basic features of (1) control of the rate of burning and the composition of the furnace gases, (2) control of the pressure inside the kiln and, (3) symmetry of distribution of the hot gases by their entering at the center of the kiln. These three features should permit the optimum results to be obtained for the combination economy of fuel and quantity and grade of ware produced, provided there were full knowledge of the relationship of the temperature cycle to the grade of ware produced, and the methods of attaining these results did not introduce secondary disadvantages.

Although the means for control were present, yet in no test was there perfection in control, partly because of lack of perfection in the means of control of the human element in using them, and because of imperfections in the controls and of failures in the structures. In addition, the temperature cycle to give optimum results was not known and almost necessarily must be largely obtained by experience for each installation, ware, and coal, unless a method of small-scale laboratory test is devised, whose results can be translated into full-scale operation.

The main objective of the investigation was not to test one particular make of stoker or to determine its structural defects, although these factors necessarily form part of investigations of this type and are of primary importance; rather, it was desired to determine the possibilities in the principle of firing with a single stoker which would be helpful to the ceramic industry and to manufacturers of stokers. Unfortunately, the

structural factor was too predominant, and caused such interruptions and delays that to date the orderly thorough investigation on the lines of the main objectives has been hampered; although the tests have not gone far enough to permit results to be expressed in complete cost values, yet a statement of results to date should help. The deductions deal more particularly with structural factors; they are classified with suggestive notes:

(1) The first installation with one stoker for two kilns was not successful for reasons previously explained. It aimed at high perfection of principle which in operation did not prove to be practicable.

(2) The movable damper, constructed of refractories held together by steel supports, which controlled the hot gases in the first installation, caused so much trouble that the conclusion was reached that a water-cooled damper would be necessary if the movable feature were retained. The introduction of water-cooling would be objectionable in most plants, and further, the heat absorbed by the water would be wasted; the natural option would be to build brick walls in the openings alternately, although this might entail some increase of the time for a complete firing cycle because of the necessity for cooling the furnace and ducts before the walls could be built.

(3) Any plan to make one stoker serve two kilns will cause an increase in length of duct, more turns, or both, than will an application to a single kiln. The right-angle turns adopted in the first installation should certainly be avoided; it is probable that a Y-construction of ducts would be better because it would reduce the resistance to flow of gases and the action on the refractories would be less severe.

(4) In the first installation the stoker was on the ground level; in the second, the contour of the ground at the plant made it easy to place the stoker below the ground level so that the hot-gas duct from the furnace was horizontal and had no fall, but it is not probable that a pit of such depth would be feasible at most plants. There is a somewhat prevalent idea that a hot-gas duct of this kind should not have a fall and that if it has, the heat cannot be passed through it as readily as though it had not. Although a fall is not desirable, particularly with natural draft, yet there is no fundamental reason why it will limit the flow of gas if there be enough stack draft or furnace pressure. Rectangular turns and falls are certainly undesirable because they entail loss of head, sweeping of the surfaces with the hottest gas, more probability of leakage, and may build up pressures or cause eddies in the rear of the furnace that will be destructive to its refractories; they are less desirable and more likely to harm the refractories with coals of low fusion ash; it would be incorrect, however, to conclude that the investigation has shown that the placing of the stoker above ground level is impossible.

(5) The design of the stoker itself and its furnace is a problem for manufacturers of stokers. They should realize that conditions of service are more severe in a Dutch oven than in installations where a stoker is placed directly under a boiler. Conditions were also more severe in these applications to kilns because there was leakage of air into the ducts beyond the furnace and this meant that the temperature of the gases in the furnace must be higher. Further, the stoker must be suited to the fuel to be used, and

frequent repairs to arches and walls, and failures that necessitate stopping during a firing should be avoided, even if the initial cost be higher.

(6) Convenient removal of the ash without the necessity of, or at least with minimum stoppage, is desirable.

(7) The minimum size of stoker to do the work satisfactorily is important. The tests here reported are a useful guide, but confirmation of these data by further firings now being made by the plant operatives is desirable. The responsibility for specifying the size must rest with the stoker manufacturer; but it is logical that he should ask for a schedule of heat requirements, data on which were rather indefinite when the size of the stoker used in these tests was decided.

(8) When deciding on the size of stoker the effect of the rate of burning on the dust carried into the flues and kiln must be considered. Data on the dust carried out are not plentiful, but some issued by the U. S. Bureau of Mines show that it depends on the coal as well as the rate of burning. The quantity of dust carried out from the fuel bed of a stoker will be greater than with hand firing because of the higher rate of burning, the agitation of the fuel bed, and the greater proportion of fine coal that is usually present in coals burned on stokers.

The quantity of dust carried into the kilns during these tests was excessive; in addition to the causes enumerated in the preceding paragraph it is probable that the fall of the ash from the rear end of the stoker into the ash-pit and the small area of the underground duct were contributory causes. Although the ware was not damaged, yet the heavy deposit entailed more labor in drawing the kiln. The quantity of dust carried into the kiln is considered to be one of the most serious disadvantages encountered in these tests and would not be allowable or tolerated at many plants.

(9) Firings were not steady enough to permit detail studies of the distribution of the gases and heat through the kiln. The central stack and underground flues gave no particular trouble except through attempts to eliminate the stack. There was some expectation that the vertically rising gases might impinge on the central portion of the crown and damage it, but the crown showed no more deterioration than occurs with hand firing.

(10) It should be recognized, however, that a symmetrical supply of hot gas from a central stack will not of itself insure uniform distribution of the gases, and that this will depend on the combined effect of the setting, floor openings, and ducts; several arrangements of floor openings were tried during these tests. The development of this method of firing has not reached a stage of perfection that will permit its use as a source of hot gases for study of the construction of kilns and settings. The distribution of heat in the kiln and setting during these early trials with accelerated rates of firing, however, has shown the importance of properly proportioned openings in the floor, and that proper setting of ware in the kiln is as important as any other feature of the design of the kiln of which the setting becomes a part.

(11) The feasibility of the underground main duct and the central stack can be taken as proved, but again, final judgment must be withheld until they have stood the test of time. The correct sizes for the main ducts are open to question, but the experiences on these tests indicated the desirabil-

ity of keeping the size large, both to reduce the resistance and to prevent the heavier dust deposit.

(12) Little definite information was gained on the benefit of having control of the pressure in the kiln. One would expect gains from it, or rather the avoidance of losses, particularly if the maximum volume is taken for the setting, and the space between it and the wall made small. Measurements of temperature showed that the distribution of heat was affected by the wind, and a pressure in the kiln should help to counteract this.

(13) The data show that the cost of firing was reduced because of the increased number of brick that could be set when the bag walls were eliminated, by the ability to follow a schedule and reduce the time of a firing, and the cheaper coal that could be used in a stoker. It is not proposed at this time to attempt to balance these gains against investment and upkeep charges.

(14) There was no reduction in labor, but this would not be expected during tests. Reduction in the labor for handling the coal and ash, and for work on the fuel bed will depend on the stoker and the ingenuity of its manufacturers. Attendance to dampers for adjustments of rates will depend on how closely a schedule is to be followed. Desire for exactitude or even for decrease in time of firing will necessitate closer attendance and probably more (or at least a new type of) skill in the operators. The relative cost of labor should, however, be on the same basis, that is, for the total time of firing, and a saving of 30% in the time will permit 30% more labor.

(15) If full advantage is to be obtained from ability to control, then means to judge the effect of or necessity for changes must be available, and suitable instruments must be included in the installation.

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HANDLING AIR[1]

By R. R. Robinson

ABSTRACT

The following points are brought out in this paper: (1) composition of air, (2) laws governing flow of air, (3) laws governing expansion of air due to temperature and pressure, (4) methods of proportioning ducts and fans as equipment for moving air (centrifugal and disk), (6) coördination of fan and duct characteristics, (7) selecting proper type of fan, and (8) use of the disk fan.

I. Introduction

A science is an orderly arrangement of facts concerning a subject. An art is the application of those facts toward the accomplishment of work.

It is the intention of this paper to discuss the art of handling air. No claim is made for presentation of original data. The purpose is rather to be as practical as possible in illustrating how certain scientific facts may be used advantageously in the ceramic industry.

II. Characteristics of Air

When any substance is to be used, it is well to consider first the composition and physical structure of that substance. Air is a mechanical mixture of gases composed according to various authorities as follows:

	Composition by volume (%)	Composition by weight
Nitrogen	78.06–79.3	75.5–77
Oxygen	21.00–20.7	23.2–23
Argon	0.94– 0.0	1.3– 0

Varying amounts of carbon dioxide, usually about 0.04 of 1%, occur.

The physical characteristics of air are those of a gas. It has weight, occupies space, absorbs heat, carries moisture, transmits light and heat, and is compressible; and when the art of handling air is practiced, the laws which are known to govern the action of air under various conditions must be kept in mind.

(1) Volume Changes When changing temperature is considered, it is found from "Charles' law" that the "volume of a perfect gas at a constant pressure is proportional to its absolute temperature."

The absolute temperature is the temperature at which a volume of a perfect gas will shrink to nothing if constantly cooled. It is based upon the fact that at 0°C a gas decreases $^1/_{273.1}$ of its volume for every decrease of 1°C. Hence, at −273.1°C or −459.6°F, the volume would be nothing. For practical purposes absolute zero is usually expressed as −460°F. As an example, if 1000 cubic feet of air at 70° is to be heated to 600°F, the volume is found as follows:

$$1000 \times \frac{460 + 600}{460 + 70} = 1000 \times \frac{1060}{530} = 1000 \times 2 = 2000 \text{ cu. ft.}$$

[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Structural Clay Products Division).

(2) Specific Heat Another property of air is its ability to absorb heat, usually called specific heat.

The specific heat of air is the ratio of the amount of heat required to raise a unit of air one degree temperature and that required to raise the same weight of water 1°. The specific heat of air under constant pressure is usually taken as 0.2415. This property of air is utilized in heating and in cooling spaces or substances.

When a building is to be heated by the use of "hot air" either in the form of waste heat from furnaces or heated air from steam coils, etc., the amount of heat necessary is first calculated (the building radiation losses and the amount of heat necessary to heat the air space within the building) and then the amount of "hot air" necessary to raise the temperature of the room is determined by making use of the "specific heat" of air.

For instance, to maintain a temperature of 60° in a certain room there are required 1,000,000 B.t.u.'s per hour. (One B.t.u. is the heat required to raise one pound water from 62 to 63°F, or one degree.)

How many cubic feet of air entering the room at 190°F will be required if the temperature of the room is to be 60°F?

Specific heat air = 0.2415
Therefore, 1 lb. loses 0.2415 B.t.u. per degree temp. drop
Temperature drop = 190° − 60° = 130°
Required 1,000,000 B.t.u. per hour

$$\frac{1{,}000{,}000}{130 \times 0.2415} = \frac{1{,}000{,}000}{31.35} = 31{,}900 \text{ lb. air / hour}$$

$$\frac{31{,}900}{60} = 532 \text{ lb./minute}$$

At 190°F, 1 lb. air contains 16.31 cu. ft.
532 × 16.31 = 8700 cu. ft./minute

In cooling ware, etc., the volume of air required may be calculated if the amount of heat contained in the ware, the rate of heat, conductivity of the ware, and the temperature of the air supply be known.

(3) Humidity Moisture as ordinarily contained in the atmosphere is in the form of vapor and behaves like a gas until the air becomes saturated when the vapor condenses to a liquid and is precipitated. The moisture-carrying capacity of air being dependent upon temperature is spoken of as "relative humidity."

The relative humidity of air is the ratio between the weight of vapor in a given volume of air at a given temperature and the total weight of vapor the air could carry at that temperature.

(4) Changes in Weight of Air The addition of vapor to the air changes the weight per cubic foot. For instance, at 70°F one cubic foot dry air weighs 0.07495 lb., while one cubic foot of saturated air at 70°F weighs 0.07425 lb. This decrease in weight is due to the fact that the vapor displaces some of the dry air which is a heavier gas.

The weight of a given volume of air is also affected by the general mete-

orological conditions and by altitude. The changes in barometer indicate higher or lower pressures in the atmosphere or denser or less dense air.

With changes of altitude the barometer is decreased by 0.1 inch mercury for each additional 100 feet above sea level.

The weight of a given volume of air, therefore, varies inversely with the absolute temperature, inversely with the relative humidity, and directly with the barometer.

When air is in motion (1) the volume varies directly with the velocity, (2) the pressure varies as the square of the velocity, and (3) the power varies as the cube of the velocity.

In duct systems these laws apply when no changes are made in the ducts.

In determining volumes of air the cross-sectional area of the duct or airway is multiplied by the average velocity.

(5) Air Pressures The pressure is ordinarily determined by means of the water gage or its equivalent. Pressures are generally expressed in inches of water column.

Air pressures are spoken of as velocity, static, and total pressure. The velocity pressure is the pressure required to create air flow. Whenever there is movement in air there is some pressure required, since air has weight and requires force to start and keep it in motion.

The discussion of pressures here will deal entirely with what is known as low pressure, namely, under 16 ounces per square inch, in which case air flow follows the usual hydraulic laws.

The power is expressed in horse power (33,000 foot-pounds per minute).

In ascertaining the velocity of air through a duct, several methods may be used. The most practical means generally employed, however, are readings by Pitot tube for high temperatures and for high velocities, and readings taken by anemometer for moderate temperatures and for velocities under 2500 feet per minute where temperatures are from 10 to 130°F.

Since some standard of measurement must be used, the force of gravity is employed and the most common liquid, water, is used to measure this force. Pressures are, therefore, generally expressed in inches of water column.

For ordinary readings a U-tube of convenient size is filled half full of clean water and connected at one end by means of a hose or pipe to the air duct. One end of the U-tube is left open to the atmosphere. When the water level in the arms of the tube is changed, the difference of levels is measured. This measurement represents the air pressure as expressed in inches of water column. For very sensitive readings, liquids of less weight are used and by applying the specific gravity of these liquids, the readings may be converted into inches of water column. Special instruments with scales arranged for liquid of definite gravity may be obtained from the manufacturers of fine instruments.

Static pressure is the pressure required to overcome the resistance of the sides and the obstructions of an airway.

Total pressure is the sum of velocity and static pressure.

It must be borne in mind that there can be no motion of air without some pressure. This fact cannot be too strongly emphasized. If the air is free to expand in all directions as soon as it leaves the agent of motion, then there is the velocity pressure required to create the velocity. If the air is confined in a directing airway, there is also the friction of rubbing surfaces to overcome in which case static pressure is developed.

III. Velocity Readings in Ducts and Airways

The anemometer, which may be used in moderate temperatures and velocities, consists of a small wheel about 4 to 6 inches in diameter having blades set at an angle to the radius. The wheel is encased in a band of metal and suspended on delicate bearings. Dials, having revolving hands which are actuated through delicate gears by the wheel, indicate the velocity in lineal feet as the wheel is turned by the air current. The instrument is held so that the air flows parallel with the axis of wheel rotation and the time of the reading is taken (usually one minute).

To obtain the volume of air flowing in a given time, the anemometer reading is multiplied by the cross-sectional area of the airway. It is important that the readings represent the average velocity of the duct.

The following method, as employed by Thomas G. Estep, Associate Professor of Mechanical Engineering, Carnegie Institute of Technology, and J. R. Robinson, President of the Robinson Ventilating Company, in large rectangular airways, is the most practical for accuracy.

The airway is sectioned into 36 sections, fine wires are strung so as to form 36 small rectangles, and the anemometer moved at five-second intervals for three minutes from one section to the next adjacent one, starting in one corner and, after traversing the airway six times, stopping at the opposite corner.

If the airway is such that a man cannot stand in it, or if it is of such size that a man's body obstructs more than 5% of the area, the anemometer may be suspended on a pole which is so graduated that the effect of a sectioned airway is obtained.

The anemometer should then be carefully calibrated and the corrections applied to the readings.

For ducts of circular cross-section, average velocities are obtained by dividing the circular area into five equal concentric areas and taking four readings in each area. To accomplish this, two traverses must be made at right angles to each other with ten readings in each traverse.

IV. Pitot Tube

Where it is not practical to take velocity readings with the anemometer,

the Pitot tube is used. This instrument consists of two metal tubes, one within the other, the whole instrument having the general appearance of the letter "L." The inner tube is open at both ends, while the outer one is closed at one end with openings in the sides. Standard specifications may be obtained from U. S. Bureau of Standards.

With the Pitot tube two gages must be used, one for indicating static pressure and one for velocity pressure. Because of its construction the tube indicates the difference between total and static pressure. The use of the Pitot tube involves a great deal of care. The short end of the tube must be inserted in the duct and the opening through which the long shank passes kept tightly closed. The tube must be pointed up-stream so that the short end is exactly parallel with the air flow. Velocity readings are taken in the positions as described for the use of the anemometer, but great care must be exercised to keep the tube pointing correctly and in the center of each small cross-section or in circular ducts at the proper radial point.

Readings are in inches of water gage. To convert these to feet per minute, temperature, barometer, and humidity corrections must be made. Ordinarily, for practical purposes, unless there is evidence of an excess of moisture, the humidity corrections may be omitted except for accurate fan testing.

To convert to feet per minute the following formula is generally used:

$$V = 1096.2 \sqrt{\frac{vp}{w}}$$

In which V = velocity ft./minute
vp = velocity pressure
W = weight in lb. of 1 cu. ft. of air

The weight of air should be taken at the observed temperature.

V. Determining Power in Air

It has been shown that air has weight and therefore requires power to start it in motion. When moving bodies of air are concentrated, especially in duct systems, the power of the moving air may be determined if the volume in cubic feet per minute and the pressure of the air is known.

Thus, if 1000 cubic feet per minute is flowing at a pressure of 0.3 in. water gage, the horse power in the air will be

$$\frac{Q \times P \times 5.2}{33{,}000}$$

Or substituting

$$\frac{1000 \times 3 \times 5.2}{33{,}000} = 0.472 \text{ air h.p.}$$

Q = quantity cu. ft./min.
P = pressure inches water gage
5.2 = pressure/sq. ft. for 1 in. water gage
33,000 = unit of h.p.

Since power must be applied to develop power, it is important that the relation between pressure and velocity be appreciated. When a constant volume is maintained the pressure and power vary as the square of the velocity, so that by doubling the cross-sectional area of the ducts, the velocity is cut in half and the pressure and power become one-fourth.

As an example: 100,000 cubic feet per minute are to be passed through a duct system which has dimensions of 5 by 5 feet or a cross-sectional area of 25 square feet. This gives $\frac{100,000}{25} = 4000$ ft. per minute velocity.

The velocity which would be created by 1 inch water-gage pressure is 4000 ft. per minute. The power in the air due to velocity only would then be $\frac{100,000 \times 1 \times 5.2}{33,000} = 15.71$ air h.p.

If the area is doubled by making the duct 7 ft. 1 in. by 7 ft. 1 in., then

$\frac{100,000}{50} = 2000$ ft. velocity or 0.25 in. water gage at 70°F

Then $\frac{100,000 \times 0.25 \times 5.2}{33,000} = 3.93$ air h.p.

$\frac{3.93}{15.71} = 0.25$

The velocity pressure is usually less than 10% of the total; therefore it is important to consider carefully the size of airway. Suppose that in the duct having 25 square feet the total pressure is 10 inches.

The total air horse power would be $\frac{100,000 \times 10 \times 5.2}{33,000} = 157.1$ air h.p., while that of the 50-sq. ft. area $= \frac{100,000 \times 2.5 \times 5.2}{33,000} = 39.3$ air h.p.

It has been stated that velocity pressure is that required to move air, while the static pressure is that required to overcome the resistance of duct wall surfaces. The total pressure varies directly with the rubbing surface, but as the square of the velocity. As an example, 100,000 cubic feet per minute passing through a duct 5 by 5 feet or a cross-sectional area of 25 sq. ft. has a velocity pressure of 1 inch water gage, while 100,000 cubic feet per minute passing through a duct 7 ft. 1 in. by 7 ft. 1 in. with a cross-sectional area of 50 sq. ft. area has a velocity pressure of 0.25 inch water gage.

Thus, with twice the area, one fourth the pressure is due to velocity.

In case of the 25-square foot duct, the total pressure is 10 inches so that the static (or pressure due to friction losses) is 10−1 or 9 inches.

While in case of the 50-square foot duct, the total pressure is 2.5 inches and the static pressure is 2.5−0.25 or 2.25 inches.

The rubbing surface of any duct system is equal to the length multiplied by the perimeter, so that given the same length, the friction would vary

directly as the perimeter. In the 25-square foot duct, the perimeter is 20 feet. While in the 50-square foot duct the perimeter is 28 ft. $3^1/_2$ in., or 28.2915 ft. The ratio of 28.2915:20 = 1.415. The ratio of total pressure is 10: 2.25, or 4.

From this comparison it is easily seen that the velocity in a duct has a much greater influence on air pressure than that of the rubbing surface.

Generally speaking, the problem of designing ducts in ceramic plants is one of carrying predetermined volumes of air or gases to or from places where work is done. The size of the duct then becomes one of a balance between the first cost and power consumed.

It has been found that the velocity pressure should not exceed 7.5% of the total for most economical results. In order to prevent high power consumption, all ducts must be designed so as to allow the air to flow with uniform velocity. Shocks or sudden changes of speed cause the power to rise. It follows, therefore, that when all outlets or inlets are to be used simultaneously these should be of such size that the volume required at each opening will pass approximately with the velocity desired in the main, and the main increased in size proportionately as the number of openings is increased.

There are, however, many limiting factors which prevent ideal design. In such cases the pressure and power required will be determined by the greatest velocities, for as a rule main ducts are constructed fairly large, but the branches or openings are often cramped. It is at these points that the power is consumed. In making turns it is well to use a large center-line radius from $1^1/_2$ to 2 times the duct radius or in rectangular ducts $1^1/_2$ to 2 times the dimension of the side which lies in the same plane as the radius of turn.

All ducts should be of as smooth construction inside as is practical and should have a uniform increase in size from the farthest inlet (or outlet) to the nearest with respect to the fan. The size of the main from the fan to the nearest outlet (or inlet) will depend upon distance and the quantity of air or gas to be handled.

For large volumes, 50,000- to 60,000-cu. ft./minute velocities should not exceed 1200 feet per minute.

VI. Movement of Air

In order that air be put in motion two distinct methods may be employed: (1) displacement by temperature difference and (2) displacement by mechanical devices or fans.

To make a brief examination of the first method, the stack or chimney may be considered. The draft in a chimney is caused by the column of air in the chimney being lighter than one of the same size outside the chimney. It, therefore, follows that stacks depend upon atmospheric conditions

for draft and that temperature and barometer changes effect changes in the velocity within the stack.

Suppose that there is a stack 50 feet high, 36 by 36 inches inside flue dimensions, and an average temperature of 900°F, the velocity within the stack when the outside temperature is 0°F would be found as follows:[2]

$$V = \sqrt{h \frac{(t_1 - t_0)}{460 + t_0}}$$

In which V = velocity (ft./min.)
h = height of stack
t_1 = av. temp. °F of stack gases
t_0 = av. temp. °F of surrounding air

Substituting, $V = 480 \sqrt{\frac{50\,(900 - 0)}{460 + 0}} = 480 \sqrt{\frac{50 \times 900}{460}}$

Velocity = 4740 ft./min. and $4740 \times 9 = 42{,}600$ cu. ft./min.

Suppose the outside temperature is 70°F.

$$V = 480 \sqrt{\frac{50\,(900 - 70)}{460 + 70}} = 480 \sqrt{\frac{50 \times 830}{530}}$$

Velocity = 4250 ft./min. and $4250 \times 9 = 39{,}300$ cu. ft./min.

Thus a rise in temperature to 70° would decrease the velocity in the stack by almost 500 feet per minute and the volume by 3600 cu. ft./min. Any change in barometer would affect the draft as the square root of the barometer difference.

When the mechanical means of moving air is considered two general classes of machines are found: the centrifugal fan and the disk fan.

The centrifugal fan is one in which the air enters parallel with and is discharged at right angles to the axis of rotation.

The disk fan is one through which the air flows parallel with the axis of rotation.

There are, generally speaking, three classes of centrifugal fans: (1) those with blades curved forward, (2) those with radial or flat blades, and (3) those with blades curved backward.

The terms forward and backward apply to the position of the blades at the periphery of the wheel with respect to the direction of rotation.

The history of fan development is interesting. Fans were probably first used in the ventilation of mines and they also gradually displaced the bellows for aiding combustion of fuels.

VII. Adaptability of Fans

There are several characteristics common to all centrifugal fans and which are used in application of these fans to the work they are to do. They may be enumerated as follows:

(1) Rim ratio: the ratio of rim speed to the speed of air due to pressure,

[2] Warren Webster & Co., Steam Heating.

(2) Volumetric capacity or efficiency: the ratio of cubic feet of air delivered per revolution to the cubical content of the fan when the wheel is considered as a cylinder.

(3) Specific speed: the speed at which a specific design of fan must operate to develop one air horse power at one inch of water gage.

(4) Ratio of total head to static head: ratio of the total pressure the fan will develop compared to the static pressure.

(5) Mechanical efficiency: based on total and static pressure, or ratio of air horse power developed to the power applied.

These characteristics are correlated and vary in unison during constant speed of operation, depending upon the resistance offered to the flow of air through the duct to which the fan is attached. The differences of operation of the three types are differences in these characteristics.

The forward curved fan has a relatively low rim ratio, high volumetric capacity, and a short range over which it will work efficiently. The radial or straight blade fan has medium rim ratio, medium volumetric capacity, and medium range of efficiency.

The backward curved fan has a high rim ratio, low volumetric capacity, high mechanical efficiency, and a wide range over which it will work efficiently.

Another characteristic which often determines the selection of the type of fan is known as rising pressure characteristic. It is the ability of the fan to increase the pressure at constant speed as the resistance in the duct system is increased beyond the point where the fan works with the best efficiency.

This characteristic is limited to the radial and backward type fan. Briefly, each type of fan is best suited to work as follows:

(1) Where large volumes at uniform pressures are to be moved and where space is limited and power cheap, the forward curve fan may be used.

(2) Where large volumes at varying pressures and where a great deal of dirt is to be encountered, the radial or straight blade fan may be used.

(3) Where high efficiencies over a wide range of pressure is desired and where power cost must be considered, the backward curved fan should be used. This fan must be larger than the forward curved fan, but is so much more efficient at its best and has so much wider range than that of the forward curved fan that where a great deal of power must be expended, this fan should be used.

Whatever type is selected for a definite work, it is important that the sizes and speed of the fan be correct. Any fan works with highest efficiency when the air flows through it with the least possible friction and without eddy currents.

Since it is characteristic of air to flow in a straight line until deflected, the air enters the intake of a fan wheel and flows parallel with the shaft until it is turned by the back plate of the wheel or the side of the casing;

or in double-inlet fans the direction of flow is changed by the central plate or by the two columns of air meeting in the center of the wheel. Thus, in passing through the wheel the air passes in a spiral direction when the fan is correct in size. The air flow just fills the wheel in such a way that the spiral flow is of uniform density across the face of the wheel and there is a smooth flow.

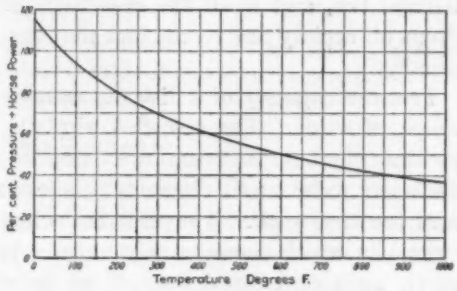

FIG. 1.—Effect of temperature on pressure and power with temperature varying. Pressure and horse power vary inversely as the absolute temperature.

If the wheel is too large the flow does not fill the wheel uniformly so that eddy currents occur which cause the fan to work inefficiently and often set up such vibration that breakage occurs.

Figure 1 illustrates the power consumption due to the size of fan

VIII. Disk Fan

In the last decade there has been an enormous increase in the use of the disk fan.

In this type of fan the air flows parallel with the shaft. This type of fan is constructed in various forms with numbers of blades ranging from a great many to two blades, as in the airplane propeller.

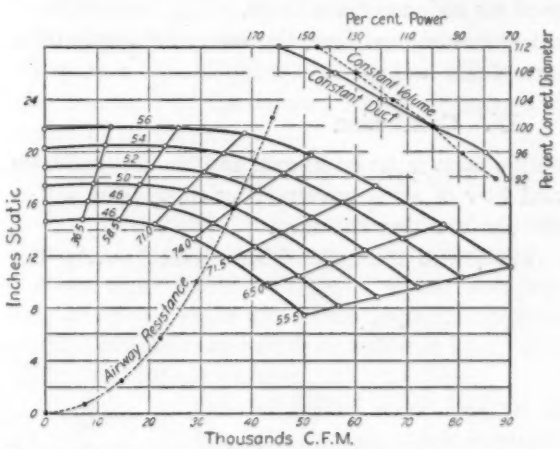

FIG. 2.—Study showing effect of wrong diameter at constant r.p.m.

The disk fan has a limited use, its field being that of moving large volumes of air at low pressures.

Since the air in passing through a disk fan flows directly through the wheel at right angles to the plane of rotation, the blades are not able to exert the proportion of force due to their rotative speed as with centrifugal fans; hence the disk fan in any of its forms is essentially a high-speed fan.

In comparison with the centrifugal fan it has a high "rim ratio." The rim must travel at a relatively high speed as compared with that of a centrifugal fan, and when the resistance of the duct increases the volume drops off rapidly due to the fact that the fan cannot build up the pressure rapidly.

Pressure capacity of a disk fan usually depends upon blade surface and shape of blade. The so-called airplane propeller fans have poor rising pressure characteristics and are therefore not at all suitable for work where ducts are to be used. In fact, it is inferior to many other types of disk fans for any work. The disk fan when operating connected to a duct system in which pressure may vary, acts partly as a screw propeller and partly as a centrifugal fan. If an infinite number of circles concentric with the axis were to be drawn (with radii constantly increasing) to the periphery of the wheel, each two circles would have different speeds as the wheel rotates, and each speed would have a certain relation to the speed of air necessary to create a certain pressure. Since the only part of the wheel through which air could flow is that which has a speed equal to or greater than the velocity which is necessary to overcome the resisting pressure, it follows that the greatest air flow through a disk fan is near the periphery of the wheel. A great deal of the air is carried around with the wheel and moves radially along the blades until reaching a point where enough pressure is developed to overcome that of the duct.

The writer's experience has been that a good disk fan must be one which has the true screw action with surface enough at the tips of the blades to carry the greater quantity of air which collects there.

As is the case, however, with centrifugal fans, the successful application involves the selection of correct size and speed.

IX. Conclusion

In handling air the scientific facts must be known and the natural laws studied since the action and flow of air is governed by those laws and is entirely independent of the fan creating the flow.

No fan will operate in violation of the natural laws which govern the flow of air.

Zelienople, Pa.

POWER CONSUMPTION IN CLAY PLANT OPERATION[1]

By J. Otis Everhart

ABSTRACT

The results of power tests on preparation and forming machinery in plant operation are presented. The effect of such variables as speed of operation, grain size, and moisture content on power consumption is also discussed.

I. Introduction

The data presented were secured at the Roseville State Brick Plant and are confined to the four operations of crushing, grinding, tempering, and forming the ware. They are supplemented by a few observations on dry-pressing operations and studies of a laboratory size auger machine.

The materials used in plant operation were largely shale with an occasional small amount of plastic fire clay when a quantity of refractories was required. The majority of observations on power consumption were made during the time that the entire production was paving brick. Some were made while building brick were being produced.

Plant practice consisted of crushing the shale body to approximately 3-inch lumps or smaller and grinding through an 8-mesh screen. The clay was tempered in a 20-foot pug mill and was formed in a combined straight-line machine which has an 8-foot pugging tub.

Apparatus used in making the tests consisted of a General Electric graphic wattmeter, one set of two General Electric air core instrument transformers, one set of two General Electric variable ratio instrument transformers, and a Weston ammeter of 5 amperes range.

Readings were taken whenever possible with the graphic wattmeter. They were checked from time to time with the ammeter. The wattmeter was returned to the factory for re-calibration during the tests and was found to be correct.

II. Laboratory Tests

Before manufacturing operations were studied, considerable work was done with a small laboratory auger machine equipped with a die for extruding 1- by 1-inch test bars. Much time was also spent with the hydraulic press used in all the dry-pressing operations at the station. These studies will be discussed first, followed by those of plant operations in the order in which they occur.

(1) Effect of Water and Grain Size

Several bodies were used in these tests. In studying the effect of moisture content on power consumption each body was prepared with barely enough moisture for working. The power necessary for extruding it

[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Structural Clay Products Division).

through a 1- by 1-inch die having zero taper was determined and small quantities of moisture were introduced at intervals. After each addition the body was worked thoroughly until the moisture was uniformly distributed. The power necessary for extrusion at each moisture content was determined. The results obtained using a plastic fireclay body are given below. These are typical of the general behavior of all the bodies studied.

Moisture content (%)	Power required (h.p.)
19.7	3.21
20.0	2.56
21.2	1.74
23.7	1.14

This effect was relatively greater than in plant practice because of the small size of the die. It is evident that a slight variation in moisture content creates a considerable variation in power consumption. A slight variation in moisture content has much more effect on power consumption when the material is dry than when it is moist.

Three bodies were prepared from the same material (a hard nonplastic shale), but having different grain sizes. The bodies were sized as follows:

Coarse body: 75% on 12-mesh; remainder factory grind.
Medium body: 75% through 12-mesh on 28-mesh; remainder factory grind.
Fine body: 75% through 28-mesh; remainder factory grind.

Equal amounts of water were added to each body. The power necessary to extrude them through the 1- by 1-inch die was determined as follows:

Coarse body: 75% on 12-mesh; 2.01 h.p.
Medium body: 75% through 12-mesh on 28-mesh; 2.34 h.p.
Fine body: 75% through 28-mesh; 3.35 h.p.

Naturally more water is required to develop the maximum workability of a fine ground body. This power increase is no doubt due largely to this factor.

Fine material apparently requires considerable more power for extrusion than does the more coarse, the other factors remaining the same.

(2) Power for Hydraulic Press The power required for press operation at various forming pressures, moisture contents, pressing surfaces, and in evacuated and unevacuated molds, was determined.

Power consumption was nearly a straight-line function of forming pressures, approximately one horse power being required for every 40-ton increment of pressure. This figure varied only slightly with moisture content and not perceptibly with a change in material. Speed was constant in this operation.

So far as has been determined it requires no more power to press over a small area than a large area, provided the total pressure is the same in each case. That is, a brick pressed at any given pressure on edge might be

pressed on the flat at the same pressure with no change in power consumption.

Moist materials require slightly less power than do dry ones, probably due to the lubricating qualities of the moisture between clay particles and the side walls of the die.

III. Plant Tests

(1) Power for Crusher

The machine in use was a McLanahan 18- by 30-inch rotary crusher. Material for the first tests was introduced in wheelbarrow lots. Later a track was installed and a dump car of 2-ton capacity placed in operation. Observations were made on both systems of feeding and on variations of size of material being prepared together with variation in quantity.

Three series of shale were made up, one of lumps averaging 5 pounds in weight, another averaging 10 pounds, and the last averaging 20 pounds. Each size of material was added to the crusher in lots varying by stages of twenty pounds from 20 to 200 pounds.

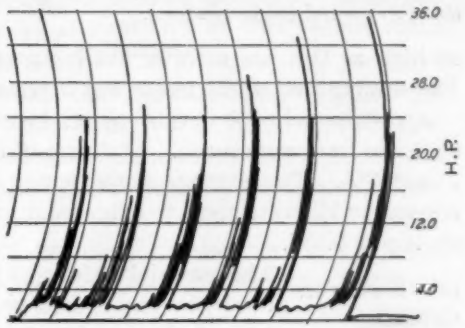

FIG. 1.—Crushing shale in two-ton lots. McLanahan 18-by 30-inch crusher, 20 h.p.

It takes approximately 15% more power to reduce the lumps averaging 10 pounds in weight than those averaging 5 pounds, regardless of quantity or rate of feeding. All tests, however, showed that one lump weighing 20

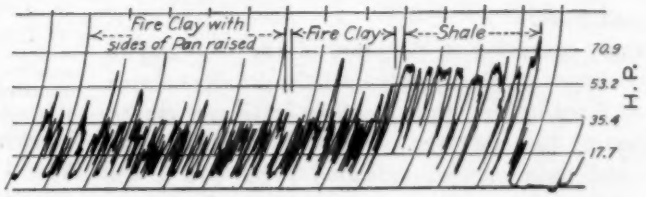

FIG. 2.—Grinding shale and fire clay. Riddell high-speed grinder, 40 h.p.

pounds could be reduced with considerable less power surge than four 5-pound lumps or two 10-pound pieces. With increasingly large quantities of material the relation assumed normal proportions requiring more power for the larger aggregate regardless of quantity thrown into the machine.

All tests showed that it is desirable to feed uniformly and continuously.

Shales differ greatly among themselves in hardness and consequently in energy necessary to reduce them to smaller sizes. Fire clays in general require much less power than do shales. The surge in power consumption when a quantity of fire clay is introduced into the machine is scarcely noticeable as compared with that resulting when a like quantity of hard shale is introduced.

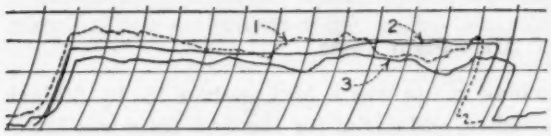

FIG. 3.—Auger machine: (1) operation without ammeter control (steam lubrication); (2) operation with ammeter control (steam lubrication); (3) operation without ammeter control (oil lubrication).

The crusher in question has a 20-horse power motor attached to it. Loads as high as this are more or less instantaneous and not at all continuous. The stalling load of the motor was determined to be 48-horse power.

Approximately 150 tons of material were being crushed in 8 hours at the time the tests were made. Moisture of crude material averaged between 2 and 3%. The average horse power consumption was 4.85 and the amount in kilowatt hours per thousand paving brick was 0.905; for builders it was 0.557.

(2) Power in Grinding

The material which was reduced to approximately 3-inch lumps by the crusher was fed into a high-speed grinder by a Jeffrey inclined apron conveyer. Both the conveyer and grinder were operated by a 40-horse power motor, belted directly to the grinder and operating the conveyer through a line shaft.

The grinder was of the newer type having 12-inch mullers rolling on a solid bottom plate. Discharge of ground material was through an adjustable slot between bottom and sides.

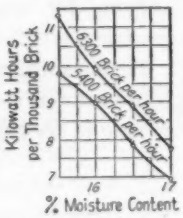

FIG. 4.—Comparative cost per 1000 brick. Auger machine operation Dunn lug pavers.

Customary operation at the start of the test was to run the conveyer at full capacity until the grinder became fairly well filled up and then to allow it to run empty before starting the conveyer. This was obviously bad practice and data secured indicated such. It is the practice now to operate the conveyer with only enough material to keep the pan comfortably filled and to continue operation without pause.

Under the method formerly employed, the power requirements were often as high as 70 horse power for a period of several minutes followed by an interval during which it would not be more than 10 or 15 horse power. Now they are able to operate at 40 to 50 horse power continuously, which is not greatly over the rated capacity of the motor.

These shales require much more power for grinding than do the fire clays. Raising the sides of the pan so that coarser particles were allowed to escape, lowered the power requirements but slowed up the production and therefore did not alter the ultimate power consumption to any great extent.

Continuous and uniform feeding are the most important factors in producing efficient operation.

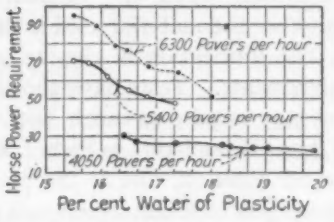

FIG. 5.—Comparative effect of moisture content on power consumption at three different operation speeds.

(3) Power for Pug Mill The mill has a 20-foot tub and is operated by a 40-horse power motor, driving through a texrope sheave. Observations were made from time to time when different amounts of material were being tempered and when various water contents were being used.

The amount of moisture being added to the material had so little effect on the power required to move it through the pugging tub that no direct relation could be determined.

The quantity of material being processed has some effect on power consumed. For example, in tempering shale for 6500 face brick per hour, an average of 23.64 horse power was required. When production was increased to 7400 brick per hour, power requirements were increased to 27 horse power and when it reached 8400 brick per hour, 30.9 horse power were required. Regardless of operating speed, cost in kilowatt hours per thousand brick remained practically stationary at 2.75.

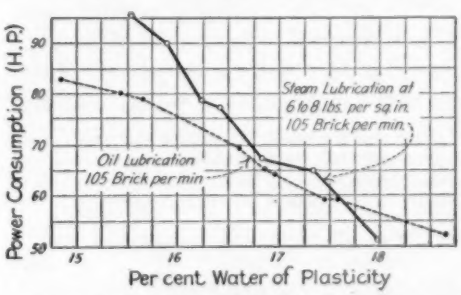

FIG. 6.—Water content of body vs. power necessary to extrude it from the die forming 105 paving brick per hour.

(4) Power for Auger Machine The machine used was of the straight-line type, having an open 8-foot pugging tub and was operated by a 75-horse power motor through a texrope drive. Observations were made at three different operating speeds, with all possible variations in moisture content.

After several tests had been made, the operator of the pug mill was provided with an ammeter attached to the motor of the mill. He was thus enabled to observe power fluctuations due to variations in moisture content and to control his material accordingly.

Moisture content is an exceedingly important factor in power require-

ments in extruding the body through a die. A variation of only 1% in moisture will cause a variation of from 20 to 40% in power requirements, depending upon the original moisture content, operating speed, and whether the material used is shale or fire clay.

Die lubrication is also an important factor in determining power requirements. Tests have shown that with low water content in the body, oil may require as much as 20% less power than does steam lubrication. When the moisture is higher, steam may require only a little if any more power than oil, due to the plastic flow of the more moist body and condensation of steam to increase die contact slippage.

Operating speed is very important in determining power requirements. When a comparatively dry body is being used a small increase in production will result in an increase in power consumption that is proportionally larger. Considering the lowest speed at which the machinery was operated, that is, 4050 brick per hour as a basis for calculating, an increase in production of 33% causes an increase of 83% in power requirements when the moisture content is 16.50%. An increase of 55% in production at that moisture content produces an increase of 153% in power consumption.

The effect is gradually diminished as the moisture content is increased. At 18% water an increase in production of 55% results in a power increase of 100% in place of the increase of 153% previously mentioned.

These studies are to be carried on at other plants using other material and different processes.

O. S. U. Engineering Experiment Station
Roseville, Ohio

SYMPOSIUM ON "VARIATION IN SIZE OF FIRE BRICK"[1]

(A) Variation in Size and Shape as It Affects the Use of Fire Brick

By James R. Allan[2]

Firebrick tolerance is of more than passing interest to the consumers and the Joint Committee on Foundry Refractories has for some time been investigating this subject. At the American Foundrymen's Association meeting in 1926, attention was called to the inferior service results obtained from poorly sized fire brick.

There has been an earnest endeavor on the part of refractory producers to grade up the refractory qualities of brick. There still remains the need of much closer tolerance on standard shapes before additional economies can be obtained.

Of all of the uses for fire brick those in melting equipment are the most severe. This is occasioned by the nature of firing, charging, and handling methods employed. Unlike other heat equipment, melting equipment requires frequent repairs and renewals of refractories. These are expensive operations in labor, brick, clay, and cement. The limited time allowed for making such repairs does not permit the brick to be selected and sorted for size and shape, grinding and rubbing joints, and other expedients resorted to in more permanent brick jobs.

Brick are usually laid in plastic fire clay which has a P.C.E. somewhat below that of the brick. The clay joints are the first to fail, either by crumbling or fusing away. Large joints either through poor bricklaying or because of considerable variation in brick size, fail more often than do small joints.

It would be natural to suppose that brick laid without plastic clay joints would give better service. This, however, is not the case as the following results covering close to 200 reverberatory furnaces show:

Average number of heats for side walls laid dry	21
Average number of heats for side walls laid in clay	24
Average number of heats for fire-box walls laid dry	35
Average number of heats for fire-box walls laid in clay	66

Fire-box bungs averaged 32 heats without clay against 46 heats with clay.

Charging bungs laid dry averaged 16 heats as compared with 20 heats laid up in clay.

Forty-seven heats were averaged for rear bungs laid dry against 49 heats laid in clay.

This all indicates that tight joints are necessary in brickwork to stop the progress and penetration of heat, flame, metal, and slag.

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[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Refractories Division).

[2] International Harvester Co., Chicago, Ill.

To improve brickwork joint efficiency, it is necessary to have joints as thin as possible so that early joint failure will not occur. If brick were made to close tolerances, it would permit the use of the higher-grade plastic clays and even possibly high-temperature furnace cements so that the joints would have some real refractory value. The use of higher-grade plastic clays and cements can only be justified generally if brick come to close limits of tolerance so that the quantity of clay or cement used per 1000 brick is greatly reduced over what is now required. High-grade fire clays cost two to three times that of ordinary fire clay, and high-temperature furnace cements about fifteen times as much.

Experiments with special large-size brick that reduce the number of joints 27%, indicate a 15% increase in service life. Other experiments in various types of furnaces, selecting the brick for uniformity and laying in cement, show an increase in service of from 5 to 25%.

All indications point to at least 10% increase in service life of refractories if close tolerances can be obtained. In addition, less clay will be used for joints and bricklaying labor will be considerably reduced.

A foundry recently has been giving serious attention to its refractory costs. Better results were obtained by using brick true in shape and size, and therefore all other brands, except the one that met this tolerance specification, were eliminated.

I witnessed a test of assembling 7 bungs with No. 105 $13^1/_2$-inch bung brick. There were 43 brick per frame. The number of brick that cracked and broke on tightening the clamps were as follows: 1, 8, 3, 1, 4, 2, 10; a total of 29 brick out of 301, which is approximately 10% broken brick. This is the best average I have ever seen, because as a rule the broken brick in clamped-up bungs run from 20 to 45%. Cracked and broken brick in bungs mean just so many more unprotected joints that eventually induce earlier failure. Breakage, of course, is due to the nonuniformity of the brick.

There is a decided tendency for many brands of fire brick to run under size. One producer made the statement that, if closer tolerances were enforced, it would mean that the consumer would have more freight to pay as the average weight for 9-inch brick would be increased from a little over 7 pounds each to 8 pounds. Adherence to close tolerances on brick on the standard dimensions will mean that the consumer will get more volume or weight, which can be translated into longer service life because of more material.

Another important advantage that close tolerances will give the large consumer is the possibility of stocking several brands of brick and being able to use them in the same job. Experience shows more or less consistent variations that are peculiar to each brand which prevents mixing of brands.

To bear out these statements of variations, the following data are compiled from 16 different brands of 9-inch straights representing 42 carloads of brick. For obvious reasons, the brands are referred to by alphabetical assignment. Carloads were measured individually.

		Length (in.)	Width (in.)	Thickness (in.)	Weight (lb.)
Brand "A"	Average of 6 cars	9.09	4.58	2.48	7.92
	Maximum " " "	9.18	4.64	2.50	8.00
	Minimum " " "	9.0	4.50	2.44	7.75
Brand "B"	Average of 5 cars	8.97	4.49	2.46	7.83
	Maximum " " "	9.04	4.55	2.50	8.2
	Minimum " " "	8.88	4.44	2.38	7.25
Brand "C"	Average of 4 cars	9.01	4.49	2.51	7.33
	Maximum " " "	9.21	4.51	2.52	7.42
	Minimum " " "	8.84	4.44	2.50	7.0
Brand "D"	Average " " "	8.87	4.45	2.48	6.84
	Maximum " " "	9.0	4.5	2.5	7.1
	Minimum " " "	8.78	4.40	2.4	6.5
Brand "E"	Average " " "	9.0	4.47	2.49	7.91
	Maximum " " "	9.0	4.5	2.5	8.1
	Minimum " " "	9.0	4.43	2.48	7.73
Brand "F"	Average of 3 cars	8.93	4.41	2.50	7.54
	Maximum " " "	9.0	4.45	2.53	7.62
	Minimum " " "	8.88	4.34	2.47	7.4
Brand "G"	Average " " "	8.95	4.44	2.47	7.08
	Maximum " " "	9.0	4.5	2.5	7.25
	Minimum " " "	8.84	4.42	2.44	6.9
Brand "H"	Maximum of 2 cars	8.61	4.22	2.37	7.0
	Minimum " " "	8.55	4.22	2.37	6.9
Brand "I"	Maximum " " "	9.1	4.51	2.57	7.88
	Minimum " " "	8.96	4.45	2.49	7.5
Brand "J"	Maximum " " "	9.08	4.49	2.51	7.4
	Minimum " " "	8.83	4.38	2.49	7.2
Brand "K"	Maximum " " "	8.95	4.46	2.49	8.2
	Minimum " " "	8.95	4.36	2.42	7.9
Brand "L"	Average of 1 car	9.0	4.5	2.5	7.25
Brand "M"	" " " "	8.75	4.19	2.38	7.0
Brand "O"	" " " "	9.0	4.5	2.5	6.75
Brand "P"	" " " "	9.0	4.5	2.5	7.25
Brand "Q"	" " " "	9.0	4.5	2.5	8.1

The maximum and minimum measurements and weights of these 42 carloads are as follows: length 9.21 to 8.55 in., width 4.64 to 4.19 in., thickness 2.57 to 2.37 in., and weight 8.2 to 6.5 lb.

The tolerances now in effect and adhered to by the producers are $\pm 2\%$ on dimensions 4 in. or over and 3% on dimensions under 4 in. To the consumer these tolerances are too great.

The tolerances mean ± 0.27 in. on the length of a $13^1/_2$-in. bung brick; ± 0.18 in. on a 9-in. dimension; ± 0.09 in. on $4^1/_2$ in., and ± 0.075 in. on $2^1/_2$-in. face dimensions.

We are suggesting the following tolerances on standard shapes: on length dimensions $\pm {}^1/_{16}$ in., or 0.0625 in.; on width dimensions $\pm {}^1/_{16}$ in., or 0.0625 in.; on face thickness dimensions $+0$, $-{}^3/_{64}$ in., or 0.046875 in.

These tolerances are proposed with particular reference to standard fireclay shapes of all qualities and for all purposes.

With reference to silica refractories for acid furnace operations and magnesite for basic operations, a committee is working on what seems to be desirable tolerances for both cold brick dimensions and working temperature sizes.

It goes without saying that the consumer realizes to some extent the problems that the producers have to meet, with the exacting specifications wanted, and that some producers are earnestly endeavoring to control the sizes. It is further gratifying to have a few of the producers state that such a tolerance specification as recommended can be adhered to by modifications made in their processes at no particular increase in the cost of production.

In other manufacturing industries the demand for closer manufacturing tolerances and higher quality and precision nearly always results in the introduction of better methods and equipment and the consequent reduction in scrap resulting in lower production cost and better satisfied customers.

Discussion

S. M. PHELPS: Mr. Allan mentioned measuring the volume of brick as supplied to his industry, and the complaint of these being under volume was received by the American Refractories Institute. The Research Advisory Committee of the Institute believed that they should obtain measurements of brick then in the stock of manufacturers of this class of refractories. Such data were obtained from companies supplying over 90% of the brick of the malleable industry. These data show that the average volume of bung brick was 100.6% of specified size and the side-wall brick showed a volume of 98.3%.

In obtaining such data, it was shown that some brands of brick were considerably oversize and others were undersize, and this brought home to some of the manufacturers the necessity of adhering to closer limits. At the present time, most manufacturers are taking every precaution to insure uniform size, and I believe you will agree, after hearing the comments which are to be given, that it would be almost impossible to comply with the size tolerance suggested by Mr. Allan. Discussion in a meeting such as this, however, will benefit both the users and producers, since each will obtain a better understanding of the problem which is involved.

R. E. BELT: About a year ago certain producers of malleable iron castings were filing complaints now and then of what they termed "serious undersizing." Inquiry was made of member companies. We asked them to report their experiences with undersizes, or with refractories in general, and the results of such tests as they might have made. Of our membership we received reports from 31 producers. Of these 31 reports, five reported no undersizes found and eight reported no undersizes of any substantial consequence. Eighteen others, however, reported that their tests indicated undersizes of serious proportions or what they termed serious proportions.

These 18 tests were tabulated. Members reported average sizes and from those average sizes the contents of their test were computed. We expressed the undersizes in relation to the standard size of the particular type of brick. In relation to the standard, the undersizes ranged from 17.1 to 3%. The cubical contents of the tests reported indicated an average undersize of cubical contents of exactly 6%.

We realize that an undersize fire brick and particularly varying sizes is not to the

best interest of the foundrymen. The more brick to be laid the greater the labor costs, and the greater the number of joints, the shorter the life of the brick. There are other factors that enter into the problem that make it a serious problem for the consumer of refractories where the tolerances are too wide.

J. R. ALLAN: Taking the average of 6% with a $43 base price on brick, that means about $2.63 worth of brick per thousand that the customer does not get.

L. A. SMITH: On the question of size and tolerance, a recent job was short 15,000 brick; 260,000 estimated to do the job had been received. The engineer who had made the estimate said the brick were too small and the bricklayer said the brick were as good as he ever got and he could not agree that a complaint on size was in order. This question has not been agreed on yet, but 15,000 more brick were bought to finish the job because this lot was 5 to 10% undersize.

We, as consumers, have been accepting undersize brick with no special complaint as long as they were straight and as long as the quantity of really small brick was kept low. On the other hand, we have done some loud complaining when certain dimensions were a trifle "full."

The matter of undersize costs us real money in three important ways: (1) we buy more brick, (2) bricklaying expense is higher, and (3) more joints makes more repairs.

The user is as much to blame as the producer for undersize brick but the maker should give the subject serious consideration because consumers are paying more attention to dimensions.

A full size brick may not be what we need because the best practice would require a brick a little less than $4^1/_2$ inches wide if it is exactly 9 inches long. This is one of the stumbling blocks in controversies on tolerance.

The statement that measurements of 31 brands of brick showed 5 brands to be full 9 by $4^1/_2$ by $2^1/_2$ inches is questioned.

E. BOGNAR: About half the output of our Imperial Plant where second quality Ohio fire brick are produced is used by engineering concerns or for projects such as power houses where specifications demand that the brick be from $^1/_{16}$ to $^3/_{32}$ inch undersized in width, length, and thickness. This demand is made because our second quality brick are used to build up the outside wall or facing, and heavier mortar joints are desired, while the inner wall is built of first-grade brick having the exact $2^1/_2$- by $4^1/_2$- by 9-inch dimensions with tight joints.

The rest of our output is sold to people calling for an exact full 9-inch brick. Needless to say it is practically impossible to make by the dry-press process in the same dies, brick of two different sizes, and use the same mix.

In downdraft kilns there is commonly a variation of from two to five cones in top to bottom when firing to 2350°F. That is the type of kiln used in the district where our plant is located, which means selection of top and bottom set brick in order to keep them in hacks according to size. Somebody must take these various sizes, or otherwise the brick that are discarded will enter into the cost price of those sold. Hence, off-size brick, which may either be over- or under-sized are often sold at a bargain or sacrifice price even though they may be perfectly good brick in every other respect. This commonly leads to a misunderstanding and general price cutting of fire brick.

(B) Variability—A General Law of Nature

By A. E. R. Westman[1]

(1) The Meaning of Data The old philosophy of measurement was based on the idea that there was a "true" value of the quantity to be measured and that any deviations of "observed" values from this "true" value were to be regarded as errors. Since only observed values could be obtained by experiment, there was the ever-present problem of trying to calculate this abstract "true" value from a set of observed values. For example, in determining the "true" strength of a brand of brick, strength determination would be made on a number of brick in a brand. From the series of observed values so obtained, an effort would be made to calculate a true value. If many observations were made, a frequency distribution[2] could be plotted giving a curve similar to that shown in Fig. 1*a*. The dot may be considered to represent the abstract "true" value on which so much emphasis was placed. The difficulties in reasoning from the curve to the dot are obvious.

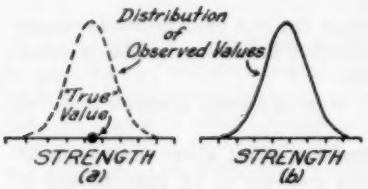

FIG. 1.

In recent years, it has been found that a much more fruitful method of thought is to discard the idea of "true" value and to pay more attention to the so-called "observed" values. These are no longer considered as attempts which have failed due to errors, but are given the consideration which is due them as experimental facts or "real" values. In other words, the starting point in the reasoning is that a certain set of experimental conditions produces a certain series of values. This is illustrated in Fig. 1*b* where the distribution of observed values is emphasized and the "true" value is omitted. This viewpoint has proved to be of very general application since it is only a matter of securing sufficiently sensitive instruments to make any set of experiments yield a series of values which show variation. This is as true of measurements of the charge on an electron as of measurements of the strengths of a brand of brick. In truth, variability is a general law of nature.

(2) The Analysis of Data Having discarded the concept of "true" value and given the observed values their due, there remains the problem of analyzing these observed values so that important questions may be answered. This problem has received intense study in recent years and powerful methods have been developed. Of particular interest are those methods of analyzing data to see how much

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[1] Ontario Research Foundation, Toronto, Canada.

[2] For details see *Jour. Amer. Ceram. Soc.*, **10** [3], 139 (1927).

control they exhibit. It would be impossible in this short discussion to show how these methods may be applied;[3] the concepts, however, on which they are based may be illustrated in a qualitative manner by the use of frequency distributions. The criteria which have been developed enable one to distinguish beween three types of production which will be described briefly. The first is characterized by lack of control, the second by control between limits, and the third by maximum control.

(3) Lack of Control The data when analyzed show that there is not a constant system of chance causes, or, in other words, that the frequency distribution of the values is changing from kiln to kiln, car to car, day to day, etc. This is illustrated in Fig. 2*a* where

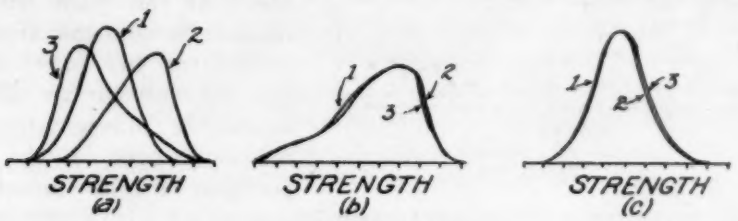

FIG. 2.

frequency distributions determined at different times are significantly different. The net effect is that there is no basis for predicting the number of values which will fall within given limits in the future.

(4) Control within Limits In this case, the nature of the distribution of values is constant and as illustrated in Fig. 2*b* frequency distributions determined at different times or from different lots do not differ significantly. In other words, there is a constant system of chance causes and a logical basis for predicting the proportion of values which will fall within given limits in the future. There are certain constant, predominating or assignable causes, however, which produce a skew distribution of the observed values and prevent maximum control. The law of mortality upon which life insurance is based is an important case of control within limits.

(5) Maximum Control The data exhibit a constant system of chance causes in which there are no predominating or assignable causes. Frequency distributions determined from different lots or at different times are in essential agreement and, in addition, give symmetrical, bell-shaped curves conforming to what is known as the normal law. This state of affairs is illustrated in Fig. 2*c*. It represents the economic limit of control for the manufacturing process in question.

[3] W. A. Shewhart, Economic Control of Quality of Manufactured Product, D. Van Nostrand Co. (in press); also Appendix 1, B-2 Report, *Proc. A.S.T.M.*, 29 [1], 200–10 (1929).

(6) What This Means to the Firebrick Manufacturer

The firebrick manufacturer has realized for some time that it is impossible for him to produce brick of absolutely constant properties. This realization has left him without an objective in his efforts to produce a uniform product. The foregoing discussion, however, has shown that this is not necessary. If his product shows lack of control, he should attempt to make it show control within limits, and finally, to make it show maximum control as defined in the previous section. At this point he has reached the economic limit of control for his particular process and further efforts should be directed toward radical changes. If the experiences of other industries are a criterion, the achievement of maximum control will bring with it other important economic advantages, *e.g.*, improvement in quality, reduction in inspection cost and sampling difficulties, ease of control of quality, attainment of uniform quality even though test is destructive, etc.

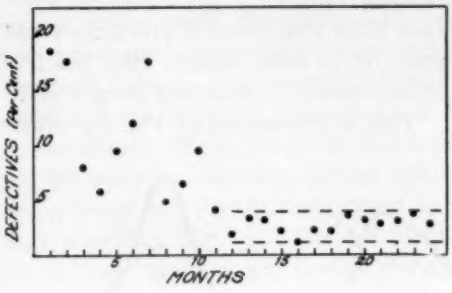

FIG 3.

An example of the improvement in quality which results from control is shown in Fig. 3 in which the per cent of defective units is plotted on a monthly basis. Maximum control was reached at the eighth month and from then on the proportions of defectives not only fell between predicted limits, but were much lower than when control was lacking.

(C) Causes of Variation in Size and Shape of Fireclay Brick

(1) Variation in Shrinkage of Clays

BY E. H. VAN SCHOICK[1]

Variation in the shrinkage of raw materials causes the greatest amount of size variation in brick and resists control most stubbornly. Although all of the other causes of variation are not yet subject to accurate control, progress is being made in that work. Eventually shrinkage of clays will be the one major problem left for study.

Causes of Variation

Causes of variation in the shrinkage of clays are obscure. Generally

[1] Chicago Retort & Firebrick Co., Ottawa, Ill.

speaking, clays high in silica will have less variation than those high in alumina; plastic clays have a higher drying and a lower firing shrinkage than flint clays, and weathered clays will shrink more than the same clays unweathered. These shrinkage differences of clays could be controlled if it were not for variations in individual clays.

Shrinkage of clay will change without an apparent change in physical characteristics or chemical composition. While plastic clays and some semiflint clays usually increase in shrinkage with increase in plasticity, hard flint clays do not give this faint clue on which to predict a change.

Variations may occur in either drying or firing shrinkage, or both. This complicates control still further; the size of the fired product cannot always be predicted from the size of the dried ware. This is especially true of mixes high in flint clay, the firing shrinkage of which is the more important factor. The fired size of brick made of siliceous plastic clays may be predicted rather accurately from measurements of the dried ware.

Methods of Control

Two methods for controlling the size of a fired product, when clays change in shrinkage are as follows: (1) by changing the size of the green brick, and (2) by varying the proportion of grog.

(1) The change in the size of the green brick involves changing the size of the molds, press boxes, or dies. With wooden molds used for handmade shapes, this can be done comparatively quickly and inexpensively, but to change the size of dies and press boxes used is serious, both as to time and expense involved. It is utterly impracticable to change machine equipment to care for periodic variations in shrinkage of the clay.

(2) Control by variation in the grog content is more practicable. Mixes with a high percentage of uniformly hard-fired calcine have practically no variation in size, but if used for the sole purpose of controlling shrinkage, their costs are prohibitive unless the highly grogged mix makes a better product.

Small additions of grog do not prevent, but they do minimize variations in shrinkage more effectively than would be considered theoretically possible. Clays which could not be made into brick within the allowable size variation without grog could be used with as little as 10% addition of grog. The addition of a second 10% of grog does not affect variations in shrinkage proportionally as does the first 10%.

Shrinkage Test Method

A relatively small amount of grog is a means of overcoming variation in shrinkage, but to control shrinkage by the use of grog, the shrinkage variations should be determined while the brick are being made. This is not easily done.

Methods for selecting and preparing samples for shrinkage tests are important. The sample must be representative of the particular clay being

used and should not be selected by picking a lump here and there. It should be representative of the whole day's run. Variations in shrinkage in the clay from the top and bottom strata of a vein will be largely obliterated by mixing at the mine, in the crushing processes, and as it passes through the bins. Therefore without due care in its selection, the sample is liable to show variations in shrinkage not possessed by the mix being used.

For shrinkage tests, small lots may be "grabbed" from each wet pan charge or from the screened clay chutes or bin feeders at least at half-hourly intervals. The entire sample thus collected, amounting to fifty or more pounds down to three or four pounds, is quartered. Small briquets, 1 by 2 by 4 inches are made, the water content being kept uniform at all times. The briquets are dried quickly and fired in a small furnace at least one or two cones higher than is usual for large kiln practice. Briquets of the size suggested can be fired to cone 13 or 14 in forty minutes in a gas-fired P.C.E. furnace, and the shrinkage can be determined within three or four hours after the samples are received in the laboratory.

While the shrinkage shown by the test briquets is not the same as shown by the brick in large kilns, all changes in shrinkage will be rather accurately foretold. The prompt discovery of such variations in shrinkage will enable the plant operator to make such changes in the grog content of the mix as his experience has shown him to be advisable.

Conclusion

One of the major causes for variation in size of fireclay brick is variation in the shrinkage of the raw materials. These variations cannot be controlled by continually changing the size of the green brick; they can be minimized, but not entirely eliminated by varying the grog content, and for purposes of shrinkage control the clay shrinkage should be predicted as accurately as is possible by the method described.

Discussion

G. B. REMMEY: Our particular plant has gone into this problem of size carefully. A few of our customers were insisting on specifications of $^1/_{32}$ inch, but the specifications applied only to the $2^1/_2$-inch dimension. In our plant we have a system of grinding that seems to be working out well for our customers. At the present time if they want us to grind the thickness of the brick within the limits of $^1/_{32}$ inch, it costs $3.00 per thousand. This is by no means a low figure because we grind but a small per cent of the brick. If every customer insisted on the brick coming within these limits, it could be ground for less money, due to the increased production.

(2) Variation in Size of Fireclay Brick Due to Firing

By George A. Bole[1]

The weight carried by the lower courses in a periodic kiln will vary from 7 to 10 lb. per sq. in. The weight on the bottom brick in a tunnel-kiln setting which is usually quite close, in some cases three on one, may amount to nearly 5 lb. per sq. in., but in an open setting the weight may be only about half this figure.

Ware set wet has been known to deform causing elongation. With dry ware and a good draft during water-smoking, the load will have very little effect until a soaking heat is reached.

The ware must be carefully oxidized, especially plastic clays containing much sulphur, iron, or organic matter. Iron and sulphur, especially with carbonaceous matter, will cause red hearts unless they are thoroughly oxidized at a dull red heat.

Every attempt is made to distribute the heat evenly through the ware in a ceramic kiln, an impossible task but relatively more successful in the tunnel kiln.

During the heating-up period in a round downdraft kiln, the temperature of the bottom is usually several hundred degrees behind the top and middle, and it is exceptional practice when a kiln finishes with less than 100°F difference between the top and bottom. This means that the top has been at a soaking heat much longer.

Heat distribution in tunnel kilns is more positively controlled. A tunnel kiln should have less than one cone difference between top and bottom. One plant reports one-half cone greater heat effect in the bottom than in the top of the setting. The variation is often greater from side to center. A kiln with as little as one cone difference from outside to inside at the finish is the exception.

A cone difference between the top and bottom of the cars may be misleading for the top of the car may have been at a soaking temperature much longer. It is possible, however, by draft manipulation to eliminate this variation by holding the heat in the bottom after the top temperature has dropped.

The best method of judging the uniformity is to compare absorption or porosity figures between the various positions in the kiln. The data will mean more than cone figures. The variation in porosity will be as high as that represented by one poor periodic-kiln practice of 30% porosity five courses from the floor to 23% at the top of the setting as compared to a variation of less than 2% in the best tunnel-kiln practice.

Periodic-kiln practice can be excellent if too great speed is not used. While good practice will vary with the ware, the mix, and the kiln, it is

[1] Ohio State University, Columbus, O.

safe to say that a periodic-kiln firing of less than seven days' duration will not produce ware of uniform porosity.

Some Missouri and Pennsylvania clays swell when heated too rapidly. F. M. Hartford of the Harrop Ceramic Service Company attributes this swelling to the too rapid decomposition of sulphates. Others attribute it to the differential shrinkage and consequent cracking and bulging of the flint clay grains. At all events it can be largely overcome by proper grind and handling of the heating schedule.

Most high-grade fireclay refractories are fired between cones 10 and 14. The kiln marking in periodic kilns usually starts about halfway down in the setting and becomes quite marked near the bottom of the setting. If the ware is formed under a sufficiently high pressure, this marking may be slight, but considerable in hand-formed ware.

Kiln marking in tunnel kilns is less than in periodic kilns, but in some cases it is apparent several courses from the bottom.

In case a kiln is held at a soaking temperature above cone 12 for twelve hours, it is evident that a load as high as 10 lb. per sq. in. will constitute quite a deforming force.

Tunnel Kiln Practice Composite replies to questions asked would be about as follows:

(1) The maximum temperature in the top of the tunnel kiln approximates 2350°F. The tip of cone 14 touches the plaque in the top of the setting.

(2) The cone obtained in the bottom of the car is approximately the same as in the top. The maximum variation throughout the kiln car is $^3/_4$ of a cone.

(3) The temperature is held within 50°F of the top temperature for 10 to 12 hours and for approximately 36 hours the temperature is above 2000°F.

(4) The approximate load on the bottom course of brick is 5 lb. per sq. in., resulting from the superimposed weight of 16 courses of 9-inch straights, set on edge (3 on 1).

(5) Kiln marking rarely occurs, but the slight marking which is occasionally found is in the bottom courses. This is due to the impingement of the flame on the bottom courses. Kiln marking is entirely prevented when sufficient pressure has been used in forming the brick.

(6) Total shrinkage of the brick on the basis of green length is approximately 2%. The fired porosity of the brick is 18 to 21%. The plastic to nonplastic ratio varies from 25:75 to 15:85. The average P.C.E. of the brick batch is cone 32 to 33.

Periodic Kiln Practice Due to the wide variation in the figures submitted on periodic kiln practice and due to the equally wide variation in figures obtained by the Bureau of Mines crew some years ago, the task of attempting to set limits on practice is difficult.

The following limits of average practice are suggested when firing the same grade of ware as in the tunnel-kiln practice:

(1) The maximum temperature in the top of the kiln will vary from 2200 to 2300°F. Depending on the length of the firing, this treatment will bring down cones 11 to 13 in the top of the wicket.

(2) This heat treatment, five courses from the bottom, will bring down cones 7 to 11. The maximum variation throughout the kiln will be from 3 to 5 cones.

(3) The temperature in the top of the kiln is held within 100°F of the top temperature for 24 hours and the temperature in the bottom is within 100°F of its maximum for 12 hours.

(4) If the kiln is tightly set, the load on the bottom course will be between 8 and 10 lb. per sq. in. and in the case of an open set, between 6 and 8 lb. per sq. in. These figures will, of course, vary with the setting system, the height of the setting, and the ware set.

(5) Kiln marking may occur through the setting, but more commonly is confined to the bottom half of the kiln. Some kilns with a tight edge set will come out with little marking in any part of the kiln.

(6) The fired porosity will vary from 12 to 20%, but a portion of the light-fired ware will be refired or else used for grog. The figures are for a high-grade refractory with a high nonplastic to plastic ratio.

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(3) Influence of Moisture Variations on the Size and Shape of Fire Brick

By L. C. Hewitt[1]

Variation in moisture may affect the size of the finished product in two ways: (1) as a variable in the raw material, and (2) as a variable in the product as molded.

Unless present in excess of that required for tempering, the effect of moisture variation is largely indirect, principally as a factor in particle size. The degree of slacking down or weathering of clays in transit or storage is governed largely by the water content and this in turn affects the grain size which has an influence upon the shrinkage or size of the finished product.

Moisture variation has a further effect upon the grain size in the grinding and screening operations. Damp clays will clog the dry-pan plates and screen openings to such an extent that many more fines are produced than if the material is dry. This in turn will affect the shrinkage.

Moisture variation in the tempering does not always have a direct relation to size variation, though in general the greater the moisture content the higher the shrinkage. As pointed out by M. C. Booze,[2] the finer the grind the greater is the amount of water necessary to develop desired

[1] Laclede-Christy Clay Products Co., St. Louis, Mo.

[2] Amer. Refrac. Inst., *Bull.*, No. 10.

plasticity because of the larger clay surfaces per mass to be covered. The evaporation of the water results in greater shrinkage in finely-ground material than in the coarse, and accordingly the matter of water content and size particles are inter-related in respect to shrinkage or size variations.

If, on the other hand, a material of constant grain size is being used, the shrinkage increase is not always in the same order with increase in water content, in that the additional water may force some of the particles apart and thus produce voids, particularly if the mixture is not sufficiently tempered.

The actual variation in water content of tempered mixes is not great in manufacturing practice. Studies by S. M. Phelps[1] on stiff-mud brick showed that the water-content difference in the softest and stiffest muds that could be used, was only 2% and this variation had little effect upon the resulting porosity. Booze[2] also showed that a small variation in water content has such a great effect upon consistency of the mud that any appreciable change is readily detected, but that in handmade products, if molders use mud of different consistency, varying shrinkages will result.

Variance in the softness or stiffness of the mud has, perhaps, a greater effect upon shape than upon shrinkage. If the mud is too soft the product may either deform as it is being taken from the mold, or squat and get out of shape on the drying pallet.

Plasticity or softness test of tempered mud for handmolding work, made by dropping a steel ball from a given height and measuring the depression, gave a maximum variation of 30% with a moisture variation of only $2^1/_2$%.

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(4) Variation in Process of Manufacture

By Cecil E. Bales[3]

Probably the most radical cause of trouble is variation in the weathering of clay. There are some firebrick plants located at considerable distances from their source of raw materials, and even those plants that are located at the mine frequently store the clay in piles. Those that are located at a distance, of course, have to store their clay to assure an adequate supply.

The clay that comes in on a rainy day may be thoroughly saturated with water. In the winter the car may be covered with snow. If that clay is taken directly to the dry pan or to the crushers, the dry-pan screen plates will become clogged. That makes the clay considerably finer on those days than it is on a dry day.

There may be some way of overcoming this problem, such as by covering

[1] Amer. Refrac. Inst., *Bull.*, No. 11.

[2] *Loc. cit.*

[3] Ironton Fire Brick Company, Ironton, O.

the clay storage piles, but there are a great many plants that have only open storage. Some plants claim that they are weathering the clay, but it is almost impossible to control this kind of weathering within the limits given by Dr. Westman. Some of the clay may be well weathered, and some may be practically raw. The more the clay is weathered the finer the grain will be; consequently, the greater the shrinkage in the brick. This item of variation will occur in all three of the processes of brick manufacture.

Under the item of handmade brick, particularly when those brick are molded and laid on the steam-heated dry floor to temper for four or five hours, unless that tempering is controlled properly there is a big variation in the finished brick. R. F. Ferguson showed several years ago that brick which are too soft are too short and thick after they are fired. Brick that are pressed when they are too dry from the hot floor, will be too long and too thin. It is possible, however, with proper control to make handmade brick quite uniform in size.

Another cause of difficulty is the common wooden molds used in molding handmade brick. Most of these molds are made from various woods. The molds become wet and then are dried. Frequently molds right out of storage may be thoroughly dried and are of a different size than when first made. This difficulty can be overcome to some extent by lining them with sheet iron or aluminum or by using aluminum molds.

Another problem is segregation in storage bins. When clays are stored in large bins the fines have a tendency to drop under where they are being spilled off the belt, and the coarse particles run out to the edge. In drawing out the clay, more fine clay or flour is obtained at some times than at others. Unless segregation in bins is overcome there will be considerable variation in the size of the brick, because the finer the clay the smaller the brick will be.

In making stiff-mud brick there are two types of dies. One die on the brick machine proper where the clay is molded and another die on the re-press machine. It is unfortunate that as soon as those dies are put in operation they begin to wear. It is true that the wear is only slight, but in two weeks or a month the wear amounts to quite a bit and naturally that will cause a variation in the size of the brick. Special alloy steels have been tried; in fact, the firebrick manufacturers are constantly trying out every type of alloy steel.

In the manufacture of dry-pressed brick, the variation in the weathering of the clay and the grind, and the segregation in the storage bins have much influence on the finished size of the ware. The amount of moisture and the way the moisture is controlled, as well as the item of pressure used in forming dry-pressed brick, exert an influence on the resultant size of brick made by that method.

In the process there is also the item of wear of the steel liners in the dies.

Some plants get only about two weeks out of a dry-pressed die lining. In that case almost every type of alloy steel has been tried.

Handmade brick are naturally the least uniform of these three processes. Some time ago it was thought that stiff-mud brick were not as uniform as dry-pressed brick, but measurements made on quite a large number of brick when checked for tolerances showed that there was not enough difference in the measurements to establish different or more lenient tolerances for stiff-mud than for dry-pressed brick. The general opinion is that dry-pressed brick are more accurate than stiff-mud, but those measurements do not show it.

Discussion

R. A. HEINDL: Mr. Bales spoke about the variation in size due to the wearing away of the molds. The Bureau of Standards has been doing work on the wearing of metals. The new alloy "Stellite" seems to have unusual prospects to prevent wearing of molds in comparison with any other material that had been tested.

C. E. BALES: Can they make a cast die liner out of Stellite, or is it welded?

R. A. HEINDL: As far as I know nothing has been done to prepare a liner. The tests have been made to determine losses due to abrasion and to compare abrasion losses of various metals which are or may be used as die liners.

C. E. BALES: Stellite is very hard and resistant to abrasion, but it is only available in the form of rods, probably $^1/_4$ inch in diameter, welded onto cast iron or steel. I do not know that it can be obtained in the form of die liners unless it is welded onto some other metal and ground down. Stellite is a very expensive material.

E. H. VAN SCHOICK: We use Stellite to put new teeth on jaw crushers and to patch up worn parts of machines. We have tried to apply it to the re-press liners, but have not been successful as yet.

R. TWELLS: The Champion Porcelain Company manufactures spark-plug cores and its experience regarding materials to resist abrasion may be of interest. The body being pugged is high in nonplastic materials and is very abrasive on the dies. A die is used until it tears the outside of the clay column or reaches the oversize limit of 0.020 inch above the normal diameter of one inch. Cold rolled-steel dies have an average life of 5 to 6 working days with a maximum of 10 working days. Annealed steel dies have a life of 32 to 35 working days. Hard steel dies last from 1 to $4^1/_2$ hours. The regular spark plug sillimanite porcelain is known to be very resistant to abrasion. Dies made from it were tried and found to have a life of 85 to 90 working days. These are now being used for regular production. Sillimanite porcelain is also being used to make taps for threading ceramic ware. These taps have much longer life than the steel taps formerly used. Whereas about 300 cores could be threaded with a steel tap, about 3000 can be threaded with a porcelain tap.

E. H. VAN SCHOICK: How closely can size-control be maintained?

R. TWELLS: Our sizes are controlled to very close limits, about 0.004. That is, 0.002 on each side of a mean. We have the die size down very close and the wear is very slow.

CHARLES H. TAYLOR: One cause of the great variation in manufacture is the variation due to actual handling of green, wet ware by labor and also the mechanical method of handling. The mere matter of taking the green brick off the power press and putting it onto a truck or pallet affects the thickness. In our method of production we feel that roughly more than 50% of our variation in thickness is due to that one cause alone.

(5) Variation in Size Due to Variation in Molding Pressure

By Raymond E. Birch[1]

The term, molding pressure, is most commonly used when employing mechanical presses in forming or reshaping. Its meaning should be broadened to cover its use in the handmade process. Variations in molding pressure occur in each of the major processes of forming refractories.

Pressure variations cause size variation only if they produce changes within the brick, which in turn cause drying and firing shrinkage variation. The clay grains are forced closer together, many grains are shattered and the smaller particles forced into the decreased voids. The clay body becomes more nearly continuous. The facilities for pyrochemical reactions are improved and a greater amount of glass may develop. The normal result would be greater firing shrinkage and less drying shrinkage.

Consistency of the batch is important. In general, the compressibility of clay is inversely proportional to the water content. Soft-mud batches will compress least of all, since the voids are largely filled with water. Stiff-mud batches should show only slightly more compressibility. Maximum compressibility occurs in power-pressing of semidry clay.

In toggle presses the clay is compressed between two male dies which are a fixed distance apart at the instant of maximum pressure. This produces uniform thickness in the green brick, but the pressure exerted on the clay depends upon the amount of clay in the mold box.

Four 9-inch straights are pressed at a time. If one mold receives more than its normal charge, that mold will receive a greater pressure. In actual production, it sometimes happens that one mold will be charged at intervals with 2 to $2^1/_4\%$ more clay than the other three molds filled at the same time. This corresponds to the difference in weight of the clots or blanks cut from the clay column to be used in forming brick by the auger machine process. In the latter process differences in the size of the clot may produce variations either in the thickness of the brick or in their density, depending upon the press construction. In the range within which most power-pressed brick are now formed a surplus of $2^1/_4\%$ of clay could cause a substantial increase in molding pressure.

Available data give[2] the relation of molding pressure to drying and firing shrinkage in eight commercial power-press batches. From these data it is possible to calculate the variations in size which could result from molding pressure variations caused by unequal amounts of clay charged to the mold. With two of the eight commercial batches studied, $2^1/_4\%$ more clay in one of the four molds would result in a fired 9-inch straight, approximately $^2/_{32}$ inch shorter than the other three brick pressed at the same time.

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[1] Harbison-Walker Refractories Co., Pittsburgh, Pa.

[2] R. E. Birch, *Jour. Amer. Ceram. Soc.*, **12** [11], 831–44 (1930).

The difference in thickness in these two extreme cases would be no more than 0.02 inch. With six of the eight commercial batches, $2^1/_4\%$ more clay would alter the fired length of the brick less than $^1/_{32}$ inch, and the corresponding differences in the $2^1/_2$-inch dimension would average only about 0.002 inch.

There is a definite maximum to which firing shrinkage is affected by change in molding pressure; this is about $^1/_{32}$ inch in a 9-inch length.

In summarizing, variations in size due to molding pressure variation occur in each of the major processes. Variations in length, however, due to this cause are slight and variations in width and thickness are negligible even by the process where the maximum effect is experienced.

Discussion

J. R. ALLAN: As for the expense of molds, I know of one foundry that has to take patterns out of the sand every seven hours and replate them with chromium because of the abrasive action of the sand.

They use Stellite on plough shares so as to get two and one-half times the service that is possible with the best heat-treated steel. The only way Stellite can be put on is by arc-welding.

Another foundry controls casting sizes by chilling; putting chills between two surfaces. A tolerance of 0.0012 inch is maintained in about 18 inches. The elements of the iron, the temperature of the iron, the density of the mold, and the wear of the pattern are controlled.

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(6) The Effect of Kiln Atmosphere on the Size of Refractories

By STUART M. PHELPS[1]

Kiln atmosphere undoubtedly affects volume change during firing more pronouncedly in some clays than in others and usually by a reducing atmosphere. In some clays a shrinkage takes place, but more often there is a pronounced expansion termed "secondary expansion." The changes seem to take place at comparatively low temperature and particularly in the lower parts of the kiln. The effects are more pronounced in periodic than in tunnel kilns, although some unusual results have been obtained in the latter, even with the more carefully controlled firing. Plant men state that these effects can be minimized by a slow rate of heating at the lower temperatures, during which period the atmosphere should be kept as oxidizing as possible.

There is little information on this subject. It has been known that ferrous silicates are less refractory than the ferric, and in the testing of clay refractories a lower refractoriness is obtained in reducing atmospheres. It would seem, therefore, that this effect would be greater in brick containing

[1] Senior Fellow, Refractories Fellowship, Mellon Institute of Industrial Research, Pittsburgh, Pa.

high percentages of iron. This has not been substantiated experimentally. Reducing atmospheres have a pronounced effect also on clays comparatively low in iron.

The Refractories Fellowship of the Mellon Institute has started a study of the causes of kiln marking. The results indicate that humid atmosphere has an effect on materials high in iron which substantiates the recommendations that care should be used during the water-smoking period. Tests have been conducted in atmospheres of hydrogen, carbon monoxide, and carbon dioxide and these show that the atmospheric condition effects changes in clays of both high and low iron contents. Apparently such changes will take place at temperatures as low as 500°C and as high as 1400°C.

The results of such a study should give information which would be of value not only in the firing of refractories, but also in their behavior in service and in the testing of refractories.

(D) Control of Variation in Size and Shape of Fire Brick

By Geo. S. Dively[1]

Manufacturing control of the size and shape of fire brick must be accomplished largely through unskilled and semiskilled labor. If we can think in terms of clay mines, some of which are quite erratic, in terms of machinery, which is always wearing and changing, and above all, in terms of the men who actually make these fire brick, it will aid considerably in grasping a practical idea of the problems involved and the control methods suggested. The human element is possibly the greatest single factor contributing to the variation in the size of fire brick.

Practical Control of Clay

The only practical control other than visual inspection is the fusion test (see Fig. 1). A separate composite sample of the hard and soft clays is taken by sampling the crushed clay from each car after it is unloaded, crushed, and conveyed to the plant storage bins. A fusion test on this weekly composite sample is made and plotted. The variation in the P.C.E. of the hard clay was reduced from four cones in one month to from one to two cones per month. Likewise, the soft clay variation has been reduced from fifteen to two cones per month. The control in this case, therefore, proved quite effective, but only insofar as the fusion test was used as a tangible guide in handling the human element. A quicker and more positive control could be devised by making daily fusion tests from the workings of each miner, but this would be practical only if some form of a portable furnace were available.

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[1] North American Refractories Co., Cleveland, Ohio.

Moisture Control Poidometers of various types have been tried but the practicability of any of them is doubtful

In the case of handmade brick, about all that is practical to do is to keep the mud as stiff as it can be molded.

In the case of stiff-mud or steam-pressed brick, moisture should average about 12%. There are, however, so many variables such as pressure, moisture, plasticity, and synchronized operation of machines, that it is often necessary to use the variable (moisture content) to obtain a satisfactory column of mud for making steam-pressed brick.

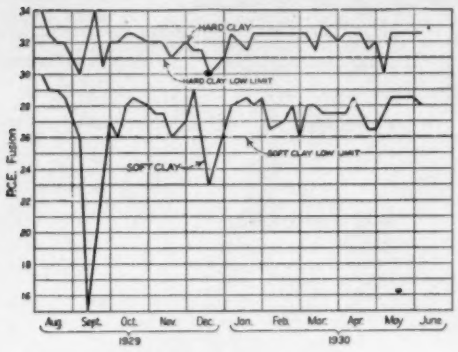

FIG. 1.

In the case of dry-pressed brick, it is practical to control the moisture content either by regulation of the quantity of water to be added to each grinding pan charge, or by daily determination of the moisture content of the dry-press material as it enters the dry press: this daily moisture determination to be used only as a guide. In general, moisture content of dry-pressed material should average from 5 to 8%, depending upon the plasticity of the clay.

Variation in Mix and Grind About all the control that can be established is to have routine screen analyses as a guide for regulating the screens and for setting up standards for the men to follow while operating the grinding pans. Once the mix is established and measuring or weighing devices installed, it is a matter of personnel management to see that proper mixes are maintained.

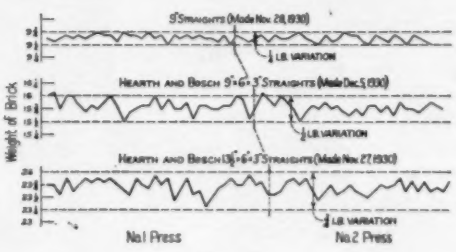

FIG. 2.

Variation in Molding Pressure On dry-pressed brick, this can be rather accurately controlled by routine weighing of the brick as they are offborne from the press on a small dial scale which is marked with a maximum and a minimum reading for each size of brick made on the press. About 3% is a normal variation to allow to take care of factors other than controllable pressure.

Likewise, on sized, double-pressed, steam-pressed brick it is practical

to hold the variation to within the same 3% limit (see Fig. 2). A standard 9-inch straight weighing from $9^1/_2$ to $9^3/_4$ pounds showed a variation of $^1/_4$ pound; a 9- by 6- by 3-Hearth and Bosch blast-furnace brick weighing $15^1/_2$ to 16 pounds showed a variation of $^1/_2$ pound; and a Hearth and Bosch blast-furnace brick weighing $23^1/_4$ to 24 pounds showed a variation of $^3/_4$ pound. These weights were obtained by weighing every tenth brick throughout one full day's run of about 15,000 nine-inch equivalents per press on each of the different sizes. It is true that these variations seem quite large, but when we consider in addition to molding pressure such variables as moisture content, press box-liner wear, and normal variation in size of the slug, it soon becomes apparent that without any control of these variables the weights would vary much more. Therefore, on the dry-press and sized steam-press processes, routine weighing of brick as they come from the press gives a rather effective and simple means of pressure control. In addition, this weighing also acts as a rough check on liner wear and moisture content. In the case of ordinary steam-pressed brick and handmade brick, however, so many other variables enter that the weight control is of no practical value.

Variation in Temperature and Load in Kilns

These variations have automatically been reduced to some extent by the use of tunnel kilns. In periodic kilns, progress has been made by setting certain shapes and large tile in a definite position on or near the top, and 9-inch straights on or near the bottom of the kiln. Therefore, even though the bottom brick will tend to be longer, narrower, and thicker, the variation will be minimized because, in general, similar classes of brick are subject to similar loads. Furthermore, variation in size and shape of brick caused by the kiln load are compensated for when calculating the shrinkage and when making the molds. Therefore, even though no direct positive control has as yet been devised to eliminate the cause of size variation caused by kiln load, the art of the industry has accomplished much in minimizing this variation.

The practice of sorting brick into separate firings has resulted from customer requirements for uniformly fired brick, *i.e.*, medium, medium to hard, and hard fired. This sorting automatically minimizes size variation resulting from difference in firing temperatures. Here again, as in the case of kiln load and in firing temperatures, control is almost entirely at the mercy of the human element; and it is largely a matter of personnel training and experience to produce satisfactory results.

Variation from Different Manufacturing Processes

It is interesting to note the actual difference in size variation of fire brick resulting from the different manufacturing processes: handmade, steam-pressed, and dry-pressed (see Figs. 3 and 4). With a $^2/_{32}$-inch average variation over four brick in the thickness in the

green state, in the fired state the variation in the case of dry-pressed brick has increased to $^{3}/_{32}$ inch, steam-pressed to $^{5}/_{32}$ inch, and handmade to $^{7}/_{32}$ inch. Furthermore, in the case of the dry-press starting with a green state variation of $^{3}/_{32}$ inch in the average width over four brick, the fired

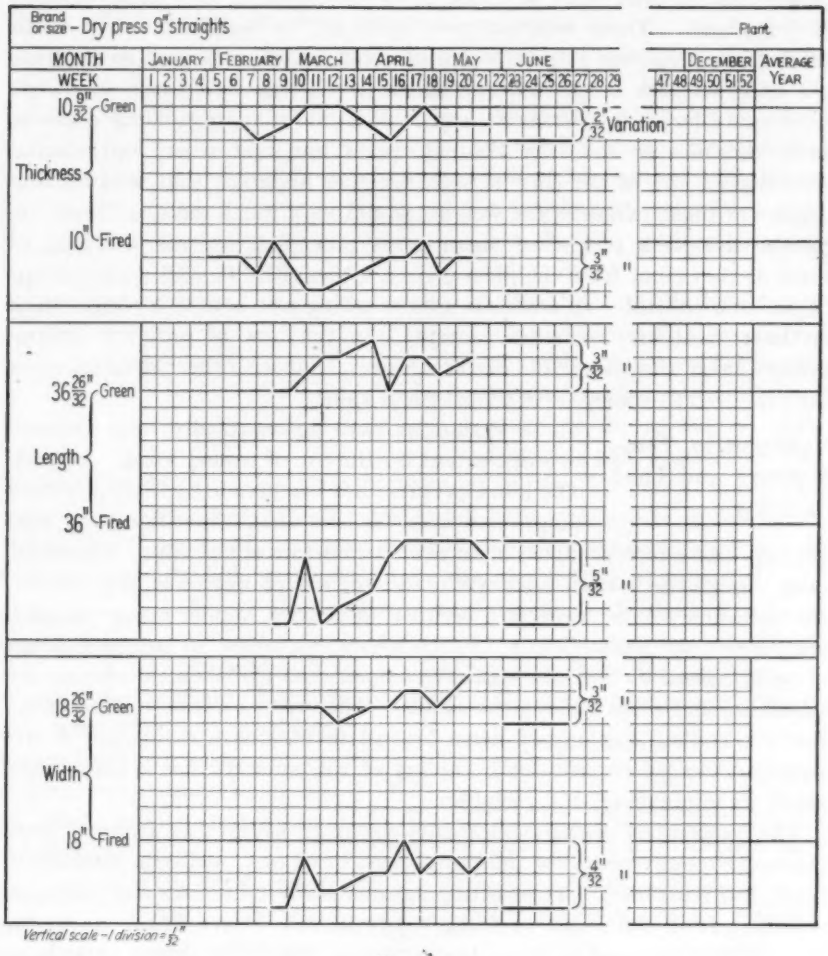

FIG. 3.

brick has $^{4}/_{32}$-inch variation; and in the case of the length, the variation increases from $^{3}/_{32}$ inch in the green state to $^{5}/_{32}$ inch in the fired state.

Size variation readings taken hourly and averaged weekly, as was the method used in obtaining the above data give plant control data in practical averages which indicate when the shrinkage of the clays is changing, when the press liners are worn out, when the average brick manufactured

by the different presses do not match in size, when the mix has been altered, and in general it gives a composite indicator of most factors that may be causing brick sizes to deviate from a set standard.

In conclusion, a plant control system must be simple; it must take into consideration averages rather than normal uncontrollable individual brick variations; it must develop practical standards for the workmen to follow

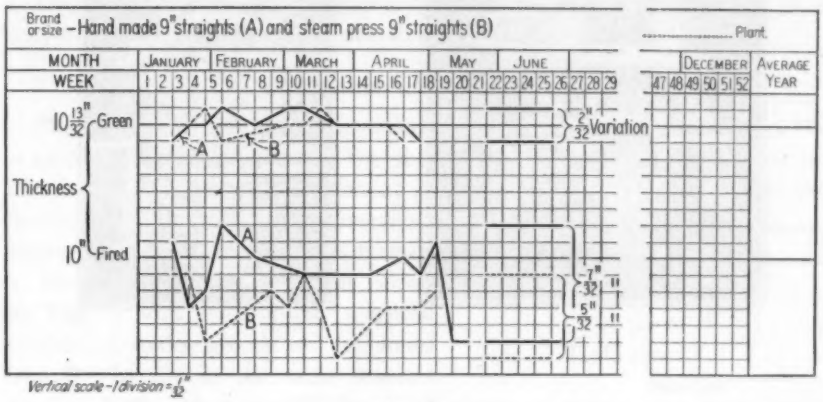

FIG. 4.

and indicators to guide the superintendent; because firebrick manufacturing is still largely an art and the greatest single factor of variation to contend with is the human element.

Discussion

A. E. R. WESTMAN: There is no conflict between the ideas presented by Mr. Dively and those advanced in my discussion on "Variability—A General Law of Nature." He is concerned with the ways and means of increasing control and undoubtedly the human factor is of great importance. His control limits are determined by his judgment as to the amount of control which it is possible to obtain under the circumstances. They may or may not agree with those which might be based on the concepts of "control between limits" and "maximum control" described in my discussion. Such limits have proved their worth in a number of manufacturing operations where many units of the product are produced daily.

(E) The Measurement of Brick and the Determination of Warpage

BY STUART M. PHELPS[1]

The method to be used for the measurement of brick has been a problem in the refractories industry for years. Production methods have decreased variation in size and this, with more rigid requirements, makes it desirable to standardize a method of measuring.

[1] Senior Fellow, Refractories Fellowship, Mellon Institute of Industrial Research, Pittsburgh, Pa.

There are a number of ways in which a brick may be measured: (1) single brick by means of a rule, (2) "go" and "Mo-go" gages, and (3) in stacks and laid side by side, obtaining an "over-all" dimension of brick,

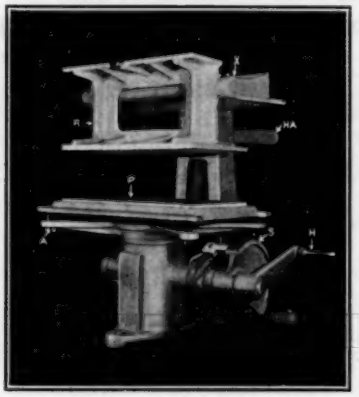

FIG. 1.

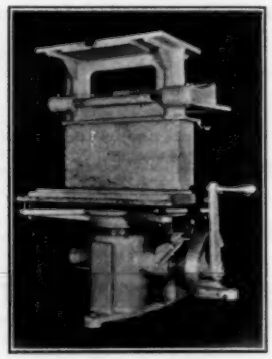

FIG. 2.

all of which are subject to personal errors. The American Refractories Institute devised the "brick meter," obtaining without personal errors the dimensions of 9-inch brick.

This device measures brick between plane and parallel plates (see Fig. 1). The brick is placed on plate, *P*. The handle, *H*, is pulled forward. This

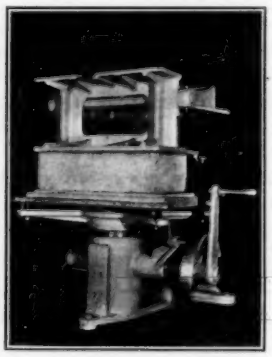

FIG. 3.

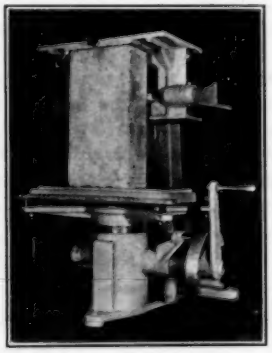

FIG. 4.

raises the plate, placing the brick in firm contact with the upper and parallel plate. In this operation the scale *S* revolves. The dimension may be read directly from it. The zero mark is in the center of the scale and on either side of it the calibration reads up to 16, representing 32nds of an

inch. The readings for a perfect 9- by $4^1/_2$- by $2^1/_2$-inch brick would be zero for each dimension; $^1/_{64}$ inch can be readily estimated.

The upper part of the brick meter indicated by the casting, *R*, revolves about the shaft, *X*, so as to be placed in the position as shown in Fig. 2. Each of the two positions of casting can be secured by a clamp actuated by the handle *H-A*. The plates are adjustable for parallelism and wear.

The brick meter insures accuracy and speed in measurements. It is not, however, easily moved since it weighs about 60 pounds.

Determination of Warpage

The customary method of measuring warpage in special shapes and tile is to place a straight edge on the surface and measure the depression by means of a rule. An improvement in this method is to make use of the device suggested by the American Refractories Institute which is termed a "measuring wedge." This is shown in Fig. 5 and consists of a small calibrated wedge which can be closed into the handle in the same manner as the blade of a jack-knife. The upper surface of the wedge is calibrated to read from the thin edge up in 32nds of an inch. In making a measurement, the straight edge is placed across the diagonal of the shape and the maximum warpage is readily obtained by sliding the wedge between the straight edge and the shape. Measurements are made on the concave side of the tile and after placing the straight edge across each diagonal the maximum warpage obtained is considered that of the shape. This method is rapid and accurate and the device might well be considered for a standard method.

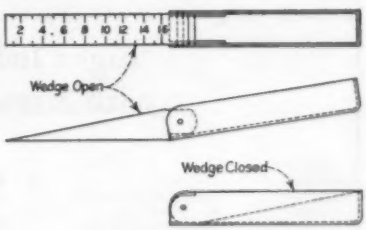

FIG. 5.

FIVE MONTHS HENCE

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Eight Industrial Divisions
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CERAMIC ABSTRACTS[1]

Compiled by the

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Vol. 10 **September, 1931** **No. 9**

Abrasives

Grain size standards are issued. Anon. *Abrasive Ind.*, **12** [7], 16–17 (1931).—U. S. Dept. of Commerce Simplified Practice Recommendation R11830 gives allowable limits for the sizing of aluminium oxide and silicon carbide abrasives for polishing and

Table I

Allowable Limits for Sizing Abrasive Grain

Grit No.	Screen through which 100% must pass	Control screen No.	Control screen Opening (in.)	Max. of oversize on control screen (%)	Min. retained (%) (Screen No.)	Cumulative min. retained (%) (Screen No.)	Max. of 3% through screen No.
10	7	8	0.0937	15	45 on 10	80 on 10 and 12	14
12	8	10	0.0787	15	45 on 12	80 on 12 and 14	16
14	10	12	0.0661	15	45 on 14	80 on 14 and 16	18
16	12	14	0.0555	15	45 on 16	80 on 16 and 18	20
20	14	16	0.0469	15	45 on 18	80 on 18 and 20	25
24	16	20	0.0331	20	45 on 25	75 on 25 and 30	35
30	18	25	0.0280	20	45 on 30	75 on 30 and 35	40
36	20	30	0.0232	20	45 on 35	75 on 35 and 40	45
46	30	40	0.0165	20	45 on 45	75 on 45 and 50	60
54	35	45	0.0138	20	45 on 50	75 on 50 and 60	70
60	40	50	0.0117	30	45 on 60	65 on 60 and 70	80
70	50	60	0.0098	15	45 on 70	70 on 70 and 80	100
80	80	70	0.0083	15	40 on 80	70 on 80 and 100	120
90	70	80	0.0070	15	40 on 100	70 on 100 and 120	140
100	80	100	0.0059	15	40 on 120	65 on 120 and 140	200
120	100	120	0.0049	15	30 on 140	60 on 140 and 170	230
150	100	140	0.0041	15	40 on 170 and 200	75 on 170, 200, and 230	270
180	120	170	0.0035	15	40 on 200 and 230	65 on 200, 230, and 270	
220	140	200	0.0029	15	40 on 230 and 270	60 on 230, 270, and 325	

Note 1: These specifications shall not apply to abrasives used in the manufacture of abrasive paper and cloth products (coated abrasives).

Note 2: The screens referred to above are those of the U. S. standard sieve series certified by the National Bureau of Standards or equivalent as shown in Table II.

Note 3: The allowable limits set forth in the above table are based on the shaking of a 100-g. sample for 5 min. on a rotap machine operated at a speed of 290 r.p.m. and 156 taps per min. Where more than one screen are used they are to be agitated simultaneously.

[1] The abbreviation (*C.A.*) at the end of an abstract indicates that it was obtained from *Chemical Abstracts* by coöperative agreement.

The bold-face number following the journal name is the volume, the issue number is in brackets followed by the page numbers, then the year in parentheses.

for grinding wheels. Standards for sieve openings and wire diameters with permissible variations are also given.

TABLE II

UNITED STATES STANDARD SIEVE SIZES

Designation (in microns) 1	Corresponding U. S. standard sieve series 2 (No.)	Sieve opening 3 (mm.)	Sieve opening 4 (in.)	Wire diameter 5 (mm.)	Wire diameter 6 (in.)	Tolerance in average opening 7 (%)	Tolerance on wire diameter (under) 8 (%)	Tolerance on wire diameter (over) 9 (%)	Tolerance in maximum opening 10 (%)
4760	4	4.76	0.187	1.27	0.050	±3	15	30	10
4000	5	4.00	0.157	1.12	0.044	±3	15	30	10
3360	6	3.36	0.132	1.02	0.040	±3	15	30	10
2830	7	2.83	0.111	0.92	0.036	±3	15	30	10
2380	8	2.38	0.0937	0.84	0.0331	±3	15	30	10
2000	10	2.00	0.0787	0.76	0.0299	±3	15	30	10
1680	12	1.68	0.0661	0.69	0.0272	±3	15	30	10
1410	14	1.41	0.0555	0.61	0.0240	±3	15	30	10
1190	16	1.19	0.0469	0.54	0.0213	±3	15	30	10
1000	18	1.00	0.0394	0.48	0.0189	±3	15	30	10
840	20	0.84	0.0331	0.42	0.0165	±5	15	30	25
710	25	0.71	0.0280	0.37	0.0146	±5	15	30	25
590	30	0.59	0.0232	0.33	0.0130	±5	15	30	25
500	35	0.50	0.0197	0.29	0.0114	±5	15	30	25
420	40	0.42	0.0165	0.25	0.0098	±5	15	30	25
350	45	0.35	0.0138	0.22	0.0087	±5	15	30	25
297	50	0.297	0.0117	0.188	0.0074	±6	15	35	40
250	60	0.250	0.0098	0.162	0.0064	±6	15	35	40
210	70	0.210	0.0083	0.140	0.0055	±6	15	35	40
177	80	0.177	0.0070	0.119	0.0047	±6	15	35	40
149	100	0.149	0.0059	0.102	0.0040	±6	15	35	40
125	120	0.125	0.0049	0.086	0.0034	±6	15	35	40
105	140	0.105	0.0041	0.074	0.0029	±8	15	35	60
88	170	0.088	0.0035	0.063	0.0025	±8	15	35	60
74	200	0.074	0.0029	0.053	0.0021	±8	15	35	60
62	230	0.062	0.0024	0.046	0.0018	±8	15	35	90
53	270	0.053	0.0021	0.041	0.0016	±8	15	35	90
44	325	0.044	0.0017	0.036	0.0014	±8	15	35	90

E.P.R.

Grinding machines. CHURCHILL MACHINE TOOL CO., LTD. *Mech. World*, **89** [2320], 580–81 (1931).—A turret universal grinding machine for grinding large porcelain insulators, etc., and a C-type plain grinding machine specially constructed for grinding crankshafts, with a swing capacity of 18 in., 72-in. length between centers, 12 table speeds, and 8 work speeds are described. The large-diameter nitralloy grinding-wheel spindle runs in plain adjustable bronze bearings that are lubricated by a pump-feed supply where oil passing to the bearings is filtered and is visible through sight-glasses situated above each bearing. Illustrated. E.P.R.

Portable electric grinder. WESTMINSTER TOOL & ELECTRIC CO., LTD. *Mech. World*, **89** [2320], 590 (1931).—This tool is equally suitable for d.-c. or a.-c. supply mains, is guaranteed to be reliable, is fan-ventilated, is fitted with a ball-bearing universal motor capable of driving a 6-in. diameter x $^1/_2$-in. face wheel under all normal working conditions, and when fitted to an ordinary lathe enables a wide range of grinding work to be carried out. Illustrated. E.P.R.

Grinder embodies novel principle. JACKSON & HUNT. *Abrasive Ind.*, **12** [7], 30

(1931).—A surface grinder has a wheel mounted on a vertical spindle, the wheel projecting through the inner and outer tables. The work is fed across the wheel.

E.P.R.

Grinding wheel safety. ANON. *Abrasive Ind.*, **12** [7], 19–20 (1931).—Speeds recommended by the Safety Code are given. Even with ample factors of safety, wheels running at more than 3000 ft./min. must have protective devices, *e.g.*, hoods, flanges, bands, or chucks. Rules for testing and mounting are given.

TABLE III

SAFE OPERATING WHEEL SPEEDS

	Vitrified and silicate bonds			Organic bonds		
Type of wheels	Soft (ft./min.)	Medium (ft./min.)	Hard (ft./min.)	Soft (ft./min.)	Medium (ft./min.)	Hard (ft./min.)
Type 1—Straight wheels	5500	6000	6500	6500	8000	9500
Type 4—Taper wheels	"	"	"	"	"	"
Types 5 and 7—Recessed wheels	"	"	"	"	"	"
Type 2—Cylinder wheels	4500	5500	6000	6000	"	"
Dovetail wheels	"	"	"	"	"	"
Types 11 and 12—Dish and flaring cup wheels	"	"	"	"	"	"
Type 13—Saucer wheels	"	"	"	"	"	"
Type 6—Deep recessed cup wheels	"	5000	5500	"	7500	9000
Coping wheels (solid and steel centers)				"	"	"
Type 1—Cut-off wheels (ordinary)					10000	12000
Type 1—Cut-off wheels (special) (Depending on stability and design of machine)						12000 to 16000

E.P.R.

Speed and accuracy by disk grinding. ANON. *Mech. World*, **89** [2318], 534–36 (1931).—The improvement in abrasives made up in the disk form, the greater skill of the foundryman in producing castings with a minimum of machining allowance, and the progress made by designers have improved disk grinding. E.P.R.

Grinding tungsten carbide semi-automatically. GISHOLT MACHINE CO. *Abrasive Ind.*, **12** [7], 30 (1931).—A grinder for giving correct rake and clearance angles to single point tools is described. E.P.R.

Grinding in bus-motor production. WHITE CO. *Abrasive Ind.*, **12** [7], 13–14 (1931).—Accuracy in grinding operations in the making of bus motors is described. Illustrated.

E.P.R.

Grinding pocket knives. ANON. *Abrasive Ind.*, **12** [7], 10–12 (1931).—Knife grinders used by the Cattaraugus Cutlery Co., N. Y., are described and illustrated.

E.P.R.

Truing abrasive disks. ANON. *Abrasive Ind.*, **12** [7], 17 (1931).—While the ordinary glue-bond disk cannot be trued effectively owing to its fragile nature, the thick abrasive circles commonly used can be trued to advantage. A star-wheel dressing tool, mounted and clamped to the disk grinder table, is fed up until the cutters just touch the rotating disk and then the table is rocked back and forth until the cutters cease to cut.

E.P.R.

Device for truing wheels accurately. CHURCHILL MACHINE TOOL CO. *Abrasive Ind.*, **12** [7], 29 (1931).—The grinding-wheel truing device incorporates a square bar mounted between the machine centers and carrying three diamond tools, two of which are adjustable by knurled screws and can be set to true the two wheels to different diameters. E.P.R.

Steadyrest makes sturdy wheel truing attachment. HECTOR J. CHAMBERLAND. *Abrasive Ind.*, **12** [7], 26 (1931).—To obviate a corkscrew finish, a machine with a capacity of 48 in. between centers where the average work is less than 18 in. and having a steadyrest is of advantage. Described and illustrated. E.P.R.

Design precision gage. ANON. *Abrasive Ind.*, **12** [7], 29 (1931).—The R. Y. Ferner Co., Washington, is marketing a new micro-indicator stand made by Société Genevoise d'Instruments de Physique, Geneva, Switzerland. The micro-indicator is mounted in the arm by an adjustment ring, by rotation of which fine settings on standard gages can be accomplished. The setting is locked by a clamp which precludes any vertical shift. Micro-indicators are available graduated to 0.0005, 0.0002, 0.0001, or 0.00005 in. per division, and carrying adjustable tolerance marks. E.P.R.

Production methods in headlight finishing. EDWARD S. HECK. *Abrasive Ind.*, **12** [7], 32–36 (1931).—The abrasive processes used in the finishing of automobile lights at the John W. Brown Mfg. Co., Columbus, Ohio, are described. E.P.R.

Automatic polisher for varied shapes. HAMMOND MACHINERY BUILDERS, INC. *Brass World*, **27** [6], 108 (1931); *Abrasive Ind.*, **12** [7], 28 (1931).—This machine is particularly adaptable in plants where an automatic equipment which can be set up for a variety of shapes and sizes in comparatively short runs is desired. See also *Ceram. Abs.*, **10** [8], 535 (1931). E.P.R.

Exhaust equipment for polishers. HISEY-WOLF MACHINE CO. *Brass World*, **27** [6], 131 (1931); for abstract see *Ceram. Abs.*, **10** [8], 535 (1931). E.P.R.

Studies in metal polishing. III. EDWIN M. BAKER AND GEORGE E. HOLBROOK. *Metal Cleaning & Finishing*, **3** [6], 485–87 (1931).—The importance of correct set-up of polishing wheels is stressed and a device for mechanically setting up is described. Drying-room conditions and the use of wheels are also discussed. Illustrated. For Part II see *Ceram. Abs.*, **10** [8], 534 (1931). E.J.V.

Polishing economy. W. RAYMOND AVISON. *Metal Cleaning & Finishing*, **3** [6], 511–12 (1931).—For efficient operation and for obtaining the greatest possible amount of wear from each wheel the following factors must be considered: (1) quality, proper handling, and heat of glue, (2) proper cleaning and warming of wheels, (3) the abrasive and its temperature, and (4) arrangement of equipment to insure convenient and speedy operation. E.J.V.

Fundamentals of machine polishing. ROBERT T. KENT. *Trans. A.S.M.E.*, **53** [10], 73–84 (1931); for abstract see *Ceram. Abs.*, **10** [4], 242 (1931). E.P.R.

What is rouge. ANON. *Abrasive Ind.*, **12** [7], 27 (1931).—Both rouge and crocus are manufactured by calcining sulphate of iron in crucibles at high temperature. The resultant powder at the bottom of the mass is crocus; that at the top, rouge. True rouge is red while crocus is purple. E.P.R.

BOOK AND BULLETINS

Electroplating with Chromium, Copper, and Nickel. BENJAMIN FREEMAN AND FREDERICK G. HOPPE. *Abrasive Ind.*, **12** [7], 26 (1931); for abstract see *Ceram. Abs.*, **9** [9], 761 (1930). E.P.R.

Machining operations. GISHOLT MACHINE CO. *Abrasive Ind.*, **12** [7], 31 (1931).—Four bulletins, Nos. 60 to 63, inclusive, present actual performance operations including machining conical faces, balancing, turning chuck bodies, and machining alloy steel screws. A tool grinding chart gives dial settings for 33 tools. E.P.R.

Tool grinder. GEORGE SCHERR CO., INC. *Abrasive Ind.*, **12** [4], 45 (1931).—Advantages of an automatic hob and tool grinder are outlined in a recent bulletin. Automatic operation reciprocating the table with compensation for backlash and automatic indexing from flute to flute or tooth to tooth are emphasized. Other features of the

machine contributing to universal adjustment and ease of operation are explained and the machine is set up for a variety of tool and cutter sharpening jobs. Illustrated. E.P.R.

Polishing and buffing. Acme Mfg. Co. *Abrasive Ind.*, **12** [4], 45 (1931).—New and redesigned polishing and buffing machines are described in this bulletin. These include a 4-spindle machine for small parts, a 4-spindle machine equipped with geared chucks and spring tension for out-of-round work, a heavy machine for radiator shells and similar work, a heavy stroke machine for such work as washing-machine tubs, and machines for polishing or buffing spherical work on a straight-face wheel. Typical types of work finished are shown. Illustrated. E.P.R.

PATENTS

Abrasive disk. Frans O. Albertson and Gustav Olsen. U. S. 1,811,037, June 23, 1931. In an abrasive device, the combination of a metal hub having an outwardly projecting attaching portion and a centrally located boss, with a resilient and flexible metal disk fixedly secured to the attaching portion and having an aperture for receiving the boss, the boss being spun outward to engage the disk, a circular cushion pad secured to the flexible disk by a plurality of rivets, the rivets being depressed in the face of the cushion pad, an abrasive disk comprising a sheet of abrasive material and a backing of fiber board, the abrasive disk pad and metal disk having a plurality of apertures, and a separate metal plate located outside the abrasive disk and having a plurality of bendable tabs for passage through the apertures in the pad and metal disk to secure the abrasive disk on the abrasive device in either of two positions.

Lens grinding and polishing machine. Ignatz G. Vetter. U. S. 1,811,219, June 23, 1931. In a device, a frame and tool support mounted therein so as to be capable of a rotary movement, a lens-grinding tool fixed on the support adapted to hold a spherical blocker for grinding, an auxiliary grinding tool mounted above the blocker for operation in opposition thereto, a support rockingly mounted in proximity to the first-named tool, a pressure device carried thereby, and means for holding the last-named support with the pressure device yieldably in position to exert pressure against a blocker held in the tools.

Truing and dressing grinding wheels. Ferdinand J. Hohnhorst and Ferdinand J. Kroeger. U. S. 1,811,933, June 30, 1931. In a machine, the combination with the grinding wheel, the tailstock, and tail spindle, the tailstock provided with an inwardly extending annular flange about the tail spindle, a pivoted frame about the annular flange, an abrading part on the pivoted frame arranged to coact with the grinding wheel, radial clamping means on the pivoted frame about the tail spindle, and arcuate clamping means between the pivoted frame and the tailstock.

Grinding machine. Waldo J. Guild. U. S. 1,812,003, June 30, 1931. The combination with a grinding machine comprising means for supporting the work, means for supporting a grinding wheel, means for producing a reciprocating motion of one of the before-mentioned means with relation to the other, means to so control the motion as to cause a relative traversing motion between the wheel and the work, one past the other in contact, or to cause the withdrawal of one from contact with the other and subsequent restoration to contact, a tool for dressing the grinding wheel so mounted that it is engaged by the wheel when the contact between the work and grinding wheel has been so interrupted, feeding mechanism to feed the work piece transverse to the traversing motion to maintain grinding contact, and separate feeding mechanism to feed the grinding wheel transverse to the traversing motion and toward the dressing tool, of devices operated directly by the first-named feeding mechanism and operable on the motion-controlling means to cause the withdrawal motion and then to restore the contacting

traversing relation of work and grinding wheel, and means for periodically moving the feeding mechanism that feeds the grinding wheel, whereby the grinding may proceed by a succession of uninterrupted traversing motions confined to the surface to be ground, and at a stage determined directly by the movement of the feeding mechanism the contact of grinding wheel and work is automatically interrupted, the grinding wheel being dressed despite wear because of its periodic advance toward the dressing tool, the traversing contact with the work being then resumed.

Grinding wheel. ALAN P. BEEBE. U. S. 1,812,076, June 30, 1931. In a grinding wheel, the combination of an open-mesh metallic reinforcement, an anchor member rigidly attached thereto, and an abrasive body in which both of the members are imbedded.

Grinding machine. WILLIAM ARTER AND WARREN F. FRASER. U. S. 1,812,313, June 30, 1931. In a grinding machine, the combination of a grinding wheel mounted to rotate in a horizontal plane, a presser head mounted above the wheel for up and down movement and operative to press the work against the wheel, means for guiding the head for vertical movement toward or from the wheel, a part connected with the head to move up and down therewith, a stop arranged to be engaged by the part, a horizontally movable wedge supporting the stop, a screw shaft bearing against the wedge, and power-operated mechanism for rotating the shaft to move the wedge in a direction to permit the stop to settle gradually and thereby limit the rate of approach of the head toward the wheel.

Grinding machine. MAXWELL I. MATHEWSON AND ARTHUR BROWN. U. S. 1,812,444, June 30, 1931. A grinding machine having, in combination, a grinding-wheel spindle and a radial thrust bearing for the spindle comprising a fixed bearing, a radial bearing block, trunnions on the block, guideways engaging therewith to position the block with relation to the fixed portion of the bearing, and spring means for forcing the block yieldingly into engagement with the spindle.

Grinding machinery. GEORGE E. MERRYWEATHER. U. S. 1,813,503, July 7, 1931. A grinding machine including a bed or support, a plurality of grinding-wheel carriages longitudinally movable thereon, means for individually imparting in and out of adjustment to the grinding-wheel carriages, a work holder mounted on the support adjacent the grinding-wheel carriages, and cam means for imparting an in and out movement to the work holder in respect to the grinding wheels.

Machine for grinding saws. EMANUEL STAUDER. U. S. 1,813,825, July 7, 1931. In a device, a saw support adapted to carry a circular saw for rotary adjustment thereon, an indexing mechanism adjacent the saw support for coöperation with a saw thereon, the mechanism comprising a head adapted to support the saw, a detent comprising a yieldable arm adapted to engage a tooth of the saw slidably mounted on the head, the detent being displaced by one tooth for automatic engagement with another, means for controlling the movement of the detent on the head, and an upstanding shaft on the base adjustable vertically thereon, the head being adjustable about the axis of the shaft.

Centerless grinding machine. SOL EINSTEIN. U. S. 1,814,209, July 14, 1931. The combination with a grinder having a regulating wheel, of an irreversible speed-reducing drive therefor comprising a close-fitting worm and worm wheel, the worm wheel being rigidly connected with the regulating wheel, an adjustable stop serving to limit the closeness of engagement of the worm and worm wheel, and resilient means urging the worm and worm wheel together.

Grinding machinery. FREDERICK J. THELER. U. S. 1,814,350, July 14, 1931. The combination, with a centerless grinder, including opposed grinding and regulating wheels and an intermediate work support, of an oscillatable, axially movable work-

positioning member disposed adjacent the throat, and means for imparting successive axial and oscillatable movements to the holder to present, withdraw, and eject a work piece.

Grinding machinery. FREDERICK J. THELER. U. S. 1,814,351, July 14, 1931. A grinding machine including a grinding wheel rotatable at a high grinding rate of speed and an opposed slowly rotating, regulating wheel member disposed in opposition to the grinding wheel but spaced therefrom to provide an intermediate work-receiving throat, the regulating wheel being rotatable at a slow work-controlling rate of speed with its operative face moving in opposition to the direction of movement of the grinding wheel, and a work carrier circumscribing the operative portion of the regulating wheel in eccentric relation thereto, the overlying portion projecting into the throat between the grinding and regulating wheels and having a plurality of terminally open pockets formed therein for support of work pieces during grinding, the width of the member being less than the minimum width of the grinding throat whereby work pieces carried thereby will project at opposite ends of the pockets for engagement, respectively, by the grinding and regulating wheels as the work pieces are carried through the throat.

Grinding machinery. CLEMENT BOOTH. U. S. 1,814,361, July 14, 1931. A machine for the production of substantially cylindrical work pieces including a work rest, a grinding wheel disposed at one side of the work rest and having its operative face moving at a high grinding rate of speed in the direction of the work rest, a work-regulating member disposed on the opposite side of the work rest and having its surface moving in the opposite direction from that of the grinding wheel to control the rate of rotation of a work piece on the machine, the rest having a work-engaging surface ascending toward the grinding wheel, and a steadying member for an over-hanging portion of the work having a work-engaging surface substantially parallel with that of the work rest and a second surface substantially parallel with that of the regulating member for simultaneous engagement with an overhanging portion of the work to steady the latter during grinding.

Centerless grinding machinery. CLEMENT BOOTH. U. S. 1,814,362, July 14, 1931. A machine for the centerless production of concentric work-piece surfaces comprising opposed grinding and regulating wheels forming a work-receiving throat therebetween, a work rest projecting within the throat for supporting work pieces therein and a work-supporting fixture mounted adjacent the throat and including a work-holding member for engaging a terminal portion of the work and oscillatable from a work-receiving position to a position to present a projecting portion of the work on the work rest in the throat between grinding and regulating wheels, and means supporting the fixture for free-floating movement to permit the work to automatically adjust itself to the grinding throat.

Grinding machinery. CLEMENT BOOTH. U. S. 1,814,363, July 14, 1931. A centerless grinder including opposed grinding and regulating wheels forming a work-receiving throat therebetween, a work-rest blade disposed within the throat, means for reciprocating the work-rest blade vertically through the throat, and a hopper for depositing work pieces on the work rest when the work rest is at its upper limit of movement.

Valve grinder. CLEMENT BOOTH. U. S. 1,814,364, July 14, 1931. A grinding machine including a work rest and a regulating wheel disposed adjacent thereto and operable at a slow work-controlling rate of speed, means disposed in opposition to the regulating wheel for urging a work piece on the rest into engagement with the wheel, means laterally displaced in respect to the regulating wheel for grinding a projecting terminal portion of the work piece, a stop for limiting axial movement of the work, and means for urging the work toward the stop during the grinding operation.

Grinding machinery. CLEMENT BOOTH. U. S. 1,814,365, July 14, 1931. A grinding machine of the centerless type including a bed or support, a grinding wheel carried there-

by and operable at a high grinding rate of speed, a work-supporting slide carried by the bed and having a work-centering mechanism projecting adjacent the operative surface of the grinding wheel, a supplemental slide carried by the first slide and bearing a regulating wheel, means yieldingly urging the regulating wheel in the direction of the work support, and means for jointly shifting the regulating wheel and work support in the direction of the grinding wheel.

Long bar grinder. JOHN E. CASTER. U. S. 1,814,367, July 14, 1931. The combination with a centerless grinder including opposed grinding and regulating wheels, of a work-supporting mechanism for presentation of work in the grinding throat between the grinding and regulating wheels including a supporting bracket, a work-rest blade carried by the bracket, means for securing the blade in adjusted position in respect to the bracket, outboard supports carried by the bracket including a series of supporting arms, rollers adjustable on the arms for alignment with the work-supporting plane of the work-rest blade, additional arms carried by the bracket, work-supporting rollers on the arms, and means for adjusting the second series of rollers for engagement with the work at circumferentially spaced points from the first series of rollers in correspondence with the circumferential spacing between engagement of the work-rest blade and the regulating wheel with the work.

Grinding machinery. JOHN E. CASTER. U. S. 1,814,431, July 14, 1931. A centerless grinder including a bed, ways on the bed, opposed grinding and regulating wheels carried by the bed, the grinding and regulating wheels having a grinding throat between them, means for rotatably supporting the grinding wheel in a fixed position on the bed, a slide on the ways of the bed, a regulating wheel unit pivotally supported on the slide, a plunger adjustably reciprocable through the regulating wheel unit, and a cam rotatably carried by the slide and adapted to engage the plunger for raising and lowering the regulating wheel unit about its pivot and urging the regulating wheel toward and from the grinding wheel to vary the grinding throat.

Grinding wheel and holder. HOBART C. BEACH. U. S. 1,814,782, July 14, 1931. In a grinding wheel assembly, a grinding wheel having one face and its periphery adapted to be used for grinding, the wheel having a projecting portion of reduced diameter on its other face, a drive shaft, and a semirigid driving connection of a diameter less than that of the wheel between the shaft and the projection on the wheel.

Grinder. JOHN W. SMITH. U. S. 1,815,014, July 14, 1931. A grinding machine for grinding spherical surfaces.

Grinding and polishing machine. R. BSTEH. Brit. 348,699, May 28, 1931.

Machines for coating grinding wheels with abrasive material. GENERAL SPRING BUMPER CORP. Brit. 349,293, June 4, 1931.

Manufacture of bonded abrasive articles. CARBORUNDUM CO., LTD. Brit. 349,602, June 10, 1931.

Continuous glass grinding and polishing apparatus. PILKINGTON BROS., LTD., AND F. B. WALDRON. Brit. 350,588, June 24, 1931; see also *Ceram. Abs.*, **9** [6], 404 (1930).

Machines for grinding rolls, etc. CINCINNATI GRINDERS, INC. Brit. 350,921, July 1, 1931.

Centerless grinding machines. CINCINNATI GRINDERS, INC. Brit. 350,957, July 1, 1931.

Grinding machines for helical gears. A. AEPPLI. Brit. 351,092, July 1, 1931.

Manufacture of artificial grinding or abrading wheels. E. A. SNOWDEN. Brit. 351,182, July 1, 1931.

Work-supporting and rotating mechanism for grinding machine. W. W. TRIGGS. Brit. 351,522, July 8, 1931.

Art and Archaeology

Colored jewelry enamels for art school use. KENNETH E. SMITH. *Jour. Amer. Ceram. Soc.*, **14** [8], 588–89 (1931).

Crystal glazes. I and II. J. WOLF. *Sprechsaal*, **64** [20], 371–74; [21], 391–93 (1931).—A bibliography of crystal glazes is given, including the German publications from 1890 to 1913. This study was undertaken mainly to check the results of G. Vogt (*Sprechsaal*, **33**, 476 (1901)). Many formulas for crystal glazes are given together with microphotographs showing the different types of crystals formed. The conditions under which the crystals are formed are discussed. W.M.C.

Modern studies in color vision. L. C. MARTIN. *Sci. Prog.*, **25**, 642–58 (1931).—Chromatic response, hue sensibility, sensation curves, visual acuity, time relations in color vision, "flickers," and the "all or none" principle are discussed in relation to the fundamental 3-color theory of Young. H.H.S.

Removal of gold decoration. H. SPURRIER. *Ceram. Ind.*, **17** [1], 48 (1931).—S. describes the removal of gold decoration from ware by the use of hot sodium cyanide solution. The method can be applied to any ware. W.W.M.

History written in glass. ELIZABETH B. PRUDDEN. *Christian Sci. Mon.*, **23** [182], 6 (1931).—The stained glass windows being designed and executed by Margaret Redmond are described. English glass is being used exclusively. Some stained glass technique is explained in detail. Illustrated. E.J.V.

Fine old English glasses. XIII. Sweetmeat glasses. FRANCIS BUCKLEY. *Glass*, **8** [1], 15 (1931). **XIV. Miscellaneous articles.** *Ibid.*, **8** [2], 65–66 (1931).—Cruet bottles, plates, rummers, and carafes are described. **XV. Bowls.** *Ibid.*, **8** [3], 102 (1931). **XVI. Two-handled glasses.** *Ibid.*, **8** [4], 146–48 (1931). For Part XII see *Ceram. Abs.*, **10** [4], 248 (1931). H.W.A.

Mexicans manufacture decorative glass windows. E. G. BOYER. *Commerce Repts.*, No. 24, p. 675 (1931).—Decorative glass, imported from the U.S., is sandblasted and stenciled, then the designs are painted with special French paints, said to be made from secret formulas. E.J.V.

Old American glass exhibit. ANON. *Nat. Glass Budget*, **47** [5], 17 (1931).—Some 300 pieces of early American glassware from the John Hays Hammond, Jr., collection, the products of Stiegel and Wister factories, were exhibited in Philadelphia in May. This glass was made at Manheim, Pa., and factories in South Jersey. The Wister glass is in nearly every respect the antithesis of Stiegel's, for it is principally window or bottle glass, the forms being frequently crude. Decorative effects were achieved by a superimposed layer of glass tooled into the so-called lily-pad and applied threading. Various color combinations were applied later. Many rare pieces are included in the collection. There are beautiful shades of amber, aquamarine, olive green, sapphire, and ruby used in wine glasses, tumblers, bowls, sauce dishes, witch balls, darning balls, mugs, jugs, pitchers, creamers, and bottles of all conceivable shapes. There are also urns, decanters, and flasks. See also *Ceram. Abs.*, **10** [3], 167 (1931). E.P.R.

Exhibits of stained glass in Metropolitan Museum. ELIZABETH LUTHER CAREY. *New York Times; Amer. Class Rev.*, **50** [38], 27–29 (1931).—There are examples ranging from the vigorous design of the 13th and 14th Centuries, in which heavy leading and the glass enframed by it interplay, the full pure colors supporting the broad darks, down to typical glass of the 17th and 18th Centuries, in which complete divorce has taken place between the design of leading and that of the painted decoration which has put on the aspect of a painted picture rather than the mosaic aspect worn by the windows of the earlier centuries. E.P.R.

Worringen beaker. ANON. *Amer. Glass Rev.*, **50** [39], 19 (1931).—The Toledo

Museum of Art collection of ancient glass recently has acquired the most important piece of engraved Roman glass extant. It is called the Worringen beaker from the locality where it was found about 100 years ago. Of 3rd Century Roman workmanship, the vessel is 8 in. high and $5^1/_4$ in. in diameter at the top. It has remained intact for 17 centuries. Of transparent, olive-tinted glass, its surface is engraved with mythological and imaginative scenes. The ornamentation shows a careful technique which includes clearly cut outlines of figures and the roughening of their inner areas to make them more conspicuous. The engraving probably was done with a diamond-pointed tool. E.P.R.

Loan exhibition of ceramic art of the Near East. M. S. DIMAND. *Bull. Met. Mus. Art*, **26** [5], 112–14 (1931).—A Persian jug with pierced decoration, lent by the estate of V. Everit Macy, is a masterpiece of technical proficiency and beauty of decoration. It was found in Sultanabad. Another example of Sultanabad pottery is a large jar covered with a deep cobalt-blue glaze lent by Horace Havemeyer. Several beautiful pieces with luster decoration show the development of the floral style from an abstract to a naturalistic one. The luster technique which was invented in Mesopotamia is one of the greatest achievements of Near Eastern ceramic art. The Rhages type of pottery with polychrome decoration from the 13th Century is represented and there are other specimens of luster ware from Rakka. Later Persian ceramic art is represented by the so-called Kubatcha ware from the 16th and 17th Centuries. A.A.A.

Polychrome vase from Centuripe. G. M. A. RICHTER. *Bull. Met. Mus. Art*, **26** [5], 123–25 (1931).—A new polychrome vase from Centuripe is being shown in the Room of Recent Accessions. In preservation and beauty of execution it is probably one of the best of its kind known. It is a large two-handled dish with a cover. It has brilliant polychrome painting, gilt decoration in high relief, and is fantastic in shape. The subject of the painting is interpreted as the performance of a mystic rite and has a resemblance to Roman frescoes of the 1st Centuries B.C. and A.D. A.A.A.

Colchester (Roman pottery). CHRISTOPHER HAWKS. *Antiquity*, **5**, 239–40 (1931).—Photographs show imported and native pottery of the 1st Century A.D. A.J.M.

Italian pottery. LEONORA R. BAXTER. *Colden Book*, **13** [78], 88–92 (1931).—The bacini or disks inset in the walls of certain churches of Pisa and other towns, are accepted as the only identified examples of a purely ornamental pottery produced in Italy prior to the Renaissance. The simple decorative process of scratching a design through a white slip covering a reddish body and the glazing of the whole with a transparent glaze was known as graffito. A tin enamel has no need of slip coating because the addition of tin oxide to a lead-rich glaze forms a dense white enamel, sufficiently opaque to disguise completely the underlying clay. Tin enamel is the outstanding feature of Italian majolica. The development of the Italian majolica is traced and some of the outstanding artists are discussed. The della Robbia family transformed terra cotta into sculpture, using colored glazes based on stanniferous enamel on terra cotta sculpture, and thereby establishing a great ceramic industry. Maestro Giogio of Gubbio developed the art of luster film to its highest point. In the latter half of the 17th Century, the art declined, partly due to the falling off of princely patronage, and partly to the advent of Chinese porcelain. Today the art is being restored and "L'Art Moderne" has begun to evolve with appealing designs and colors. Majolica is and always has been pottery, not porcelain, and has qualities which make it one of the most beautiful forms of art. Illustrated. E.J.V.

Tile stoves of Switzerland. ANON. *Christian Sci. Mon.*, **23** [174], 9 (1931).—The unique tile stoves of Switzerland which are the country's chief contribution to ceramic art have evolved through three stages of development. At first they appeared as purely architectural accomplishments decorated with plastic structure, usually round though

occasionally quadrangular. The color scheme was generally monochrome, most of the tile showing a green glaze. The second phase presents a work of plastic art with the tile receiving a strongly impressed relief with a wide variety of ornamentation. The art of painting was adopted in the third stage. The plastic element of its structure and ornamentation receded and the brilliancy of colors gained, culminating in delightful polychromy. Glazed oven tile were first used for stoves in Switzerland as early as the 14th Century. Illustrated. E.J.V.

Irving Trust Co. ANON. *Arch. & Bldg.*, **58** [3], 70 (1931).—The main reception hall of the Irving Trust Co. has narrow cathedral windows on three sides which are finished in glass mosaic. Ruby-red glass with gold tracery is used in the lighting. E.P.R.

Style trends. ANON. *Ceram. Ind.*, **17** [1], 42–47 (1931).—Information on style trends of dinnerware, glassware, and toilet articles, as obtained from interviews with officials of leading manufacturers and New York wholesale and retail houses, is presented. Simple and subdued colors are most popular at present. W.W.M.

Display. ANON. *Pottery Caz.*, **56** [649], 988–90 (1931).—The various ways of making effective displays are explained and examples cited. Illustrated. E.J.V.

BOOKS AND CATALOGUE

Books on Persian art. ANON. *Times Lit. Supp.*, **30,** 17–18 (1931).—A connected review is given of the following books: Denison Ross's The Persians, Pope's Introduction to Persian Art (see *Ceram. Abs.*, **10** [6], 406 (1931)), Dimand's Mohammedan Decorative Arts (*Ibid.*), Mulk Raj Amand's Persian Painting, and others. H.H.S.

Excavations at Olynthus. Part II. Architecture and Sculpture. D. M. ROBINSON. xxii + 155 pp., 307 plates. Johns Hopkins Univ. Press, Baltimore, 1931. Price $21.50. Reviewed in *Times Lit. Supp.*, **30,** 286 (1931).—Olynthus was laid waste by Philip of Macedon in 348 B.C., and has never again been inhabited. H.H.S.

Decorative Patterns of the Ancient World. FLINDERS-PETRIE. xvi + 88 pp. Quaritch, London, 1931. Price 21s. Reviewed in *Times Lit. Supp.*, **30,** 289 (1931).—The book is arranged according, not to date or country, but to subject: foliage, rosette, spiral, cross, zigzag, etc. H.H.S.

Corpus of Dated Palestinian Pottery. J. G. DUNCAN. 21 pp. 120 plates. British School of Archaeology in Egypt, London, 1931. Price 30s. Reviewed in *Times Lit. Supp.*, **30,** 269 (1931).—The pottery includes Hyksos pottery from Egypt, Cappadocian specimens, and ware recently discovered at Byblos. H.H.S.

Annual of British School of Athens. Vol. 29. ANON. x + 351 pp., 25 plates. Macmillan & Co., London, 1931. Price 3 guineas. Reviewed in *Times Lit. Supp.*, **30,** 289 (1931).—On the careful stratigraphic observation of the pottery found depends the reconstruction of early history. The results are said to be an object lesson in scientific archaeology. H.H.S.

Catalogue of Roman Pottery in the Colchester and Essex Museum. THOMAS MAY. Price 63s. Reviewed in *Antiquity*, **5,** 251–52 (1931); for abstract see *Ceram. Abs.*, **10** [2], 95 (1931). A.J.M.

PATENTS

Design for bottle. JOHN E. FOWLER. U. S. 84,469, June 23, 1931. THOMAS S. HARRIS. U. S. 84,476, June 23, 1931. MEYER RICH. U. S. 84,649, July 14, 1931.

Design for plate. EDWIN HALE. U. S. 84,474, June 23, 1931. GEORGE FULTON. U. S. 84,520, June 30, 1931. ROBERT C. RICHARDSON, JR. U. S. 84,651, July 14, 1931.

Design for water closet bowl. GEORGE BRAIN. U. S. 84,458, June 23, 1931.

Design for water jug, etc. JESS CLAIR KELLY. U. S. 84,482, June 23, 1931.

Design for lavatory. CARMI J. STEELE. U. S. 84,498 and 84,499, June 23, 1931.

Design for bathtub. CARMI J. STEELE. U. S. 84,500, June 23, 1931.

Design for jar, etc. THEODORE J. PIAZZOLI. U. S. 84,593, July 7, 1931.

Decalcomania and decalcomania paper. ALFRED B. POSCHEL. U. S. 1,811,804, June 23, 1931. A decalcomania paper particularly adapted for high-speed offset printing presses, comprising a paper stock, a water-soluble coating, and a nonwater-soluble coating placed on top of the water-soluble coating, the nonwater-soluble coating having as one of its ingredients a drier capable of drying the ink deposited thereon from even high-speed offset printing press.

Manufacture of colored patterned glass and other transparencies or translucencies. BASIL RICHARD BAYNE. U. S. 1,813,901, July 14, 1931. A method of manufacturing colored patterned glass wherein individual elements of glass are first caused to adhere to a glass base by means of an adhesive and flux to form the design, the whole being then fired at a suitable temperature to cause the elements to become fused through the flux to the glass base and then filling in the interstices between the elements to form a mosaic-like design on the base substantially as described.

Determining the intensity of colors. J. RAZEK AND P. J. MULDER. Brit. 349,565, June 10, 1931.

Process of and means for decorating ceramic objects. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER. Brit. 351,531, July 8, 1831; see also *Ceram. Abs.*, **10** [2], 96 (1931).

Cement, Lime, and Plaster

Further information on the alite controversy. A. GUTTMANN AND F. GILLE. *Zement*, **20** [12], 144–47 (1931); *Pit & Quarry*, **22** [5], 72 (1931).—Since Guttmann and Gille's last researches on the composition of alite which, on the basis of chemical, optical, and X-ray investigations, was described as almost pure tricalcium silicate (see *Ceram. Abs.*, **9** [4], 254 (1930); **10** [3], 172 (1931)), there has been a lively controversy. Guttmann and Gille repeat that existence of $3CaO \cdot SiO_2$ can no longer be doubted; that alite, the principal constituent of Portland cements with high lime contents, is neither a bicalcium-silicate enriched with lime (Dyckerhoff) nor a mixed crystal of aluminate rich in lime, or Jäneckeit, and tricalcium silicate (see *Ceram. Abs.*, **9** [4], 262 (1930); **10** [6], 408 (1931)), nor a mixed crystal of tricalcium aluminate (earlier reports of Guttmann and Gille), nor a mixed crystal of Jäneckeit and bicalcium silicate (see *Ceram. Abs.*, **9** [4], 255 (1930)), nor is bicalcium silicate the bearer of the alite (Nacken), but alite is tricalcium silicate, and a part of the alumina is combined in the celite (essentially $4CaO \cdot Al_2O_3$ $(Fe, Mn)_2O_3$), the excess being found in the clinker as free aluminate. At the end of this discussion is given a brief summary of the history of the "alite question" since Le Chatelier in 1884 asserted, on the basis of analyses of the grappiers, that tricalcium silicate is the principal source of the hydraulic hardening of Portland cement. See articles by Jänecke (*Ceram. Abs.*, **8** [12], 866 (1929)), Spangenberg (*Ceram. Abs.*, **10** [7], 481 (1931)), and Sestini (*Ceram. Abs.*, **10** [8], 543 (1931)). E.P.R.

Researches on the rotary kiln in cement manufacture. XIX. Weights of dry slurry used and weights of carbon dioxide and moisture expelled therefrom in producing different weights of clinker. GEOFFREY MARTIN. *Rock Prod.*, **34** [11], 58–59 (1931). **XX. Calculation of the exit temperatures of gases from a rotary kiln, using incoming air preheated to different temperatures by outgoing clinker, no external or internal radiation losses occurring.** *Ibid.*, **34** [12], 45–47 (1931). **XXI. Loss in clinker output due to external radiation losses from a modern rotary kiln.** GEOFFREY MARTIN. *Rock Prod.*, **34** [13], 52–53 (1931).—While "heat balances" of rotary cement kilns have frequently been determined experimentally and the results widely published, M. believes

these are of little practical value because they do not differentiate between high-grade heat (above 1481 °F). As long as there is enough low-grade heat to dry the raw materials and heat them to the calcination temperature, the efficiency of a kiln depends upon the effective use of the high-grade heat units. There is almost always a surplus of low-grade heat. A table is presented, showing savings that would be effected by stopping all external radiation from the clinkering and decarbonating zone of the kiln shell.

XXII. Loss in clinker output due to internal radiation losses from a modern rotary kiln. *Ibid.*, **34** [14], 40–43 (1931).—M. describes the loss of high-grade heat within the rotary kiln. This is much greater than the loss through external radiation. A table is given of calculated radiation losses from the kiln under varying conditions. A second table shows comparative fuel requirements under average operating conditions with (1) external losses eliminated, (2) internal losses eliminated, and (3) both of these eliminated. This table shows the importance of this loss of heat on the cost of production of clinker and in turn the cost of cement. For Part XVIII see *Ceram. Abs.*, **10** [7], 481 (1931). W.W.M.

Waste-heat saving in production of fused cement. W. MARSCHNER. *Zement*, **20** [16], 362–63 (1931); *Rock Prod.*, **34** [14], 85 (1931).—M. cites E. Schirm on the excessive cost of electrically fused cement due to the high discharging temperature necessary. He then describes a patent applied for by M. Platsch, in which this high discharge temperature is taken advantage of by mixing cold raw bauxite and lime with the fusion as it is discharged from the kiln. This raw mixture, in contact with the liquid fused cement, combines below 1400 °C to form fused cement. This addition does not affect the binding ability and strength of the original cement. W.W.M.

Hardening problem of Portland cement. KARL E. DORSCH. *Zement*, **20** [13], 296–97 (1931); *Rock Prod.*, **34** [14], 85 (1931).—D. obtained pure calcium oxide and ground it as fine as cement. He made suspensions of this material in water, dilute gypsum solution, and saturated gypsum solution. Similar suspensions were made using Portland cement in place of the lime. The suspensions were sealed in test tubes and microscopic examinations were started after a few days and continued several weeks. No essential difference was noted between the lime and the Portland cement suspensions. Most of the crystals formed were gypsum with an occasional calcium hydroxide crystal. In the gypsum solutions the amorphous calcium-hydroxide particles were a little larger than in the water solutions. W.W.M.

Effect of certain admixtures on Portland cement. ANON. *Zement*, **20** [2], 192–93 (1931); *Pit & Quarry*, **22** [7], 83 (1931).—Marl, chalk, and dolomite, dried and ground, were mixed with cement in proportions of 1, 2, 5, 10, and 30% and tested in 1:3 mixes according to standard procedure. The tensile strength of the "pure" cement is somewhat higher than that of the "mixed" cements, the compressive strength of the latter in many cases surpassing that of the pure cement. The effect of chalk, dolomite, marl, and other neutral admixtures is partly densifying, partly absorbent. The solution arising from the hydration coagulates to a jelly and the whole mass becomes more dense. The particles of admixture are inclosed and distributed in the colloidal jelly and are covered with jelly. E.P.R.

Characteristics of blast-furnace slag slurry in Portland cement manufacture. L. N. BRYANT. *Rock Prod.*, **34** [14], 52–57 (1931).—B. cites advantages of blast-furnace slag as an ingredient of Portland cement, comparing clay-limestone and slag-limestone mixtures. He discusses advantages and disadvantages of the wet process, the use of filters to prevent slurry troubles, and the characteristics of slag slurries. A large amount of research was done on the effects of various electrolytes on the slurries. The effects of temperature and increased dilution of slurry were also studied. The colloidal behavior of slurry is discussed and a theory is advanced for the congealing of blast-furnace slag

slurry. Graphs are included to illustrate the results of experiments. The effect of congealing on filtration and drying efficiency is shown. W.W.M.

Deterioration of porous cement. G. NATTA AND C. G. FONTANA. *Giorn. chim. ind. applicata*, **13** [4], 173–78 (1931).—An excess of fine constituents in the sand, the incorrect grain size of the composition and probably excess water in the paste, and the use of cement containing a high per cent of inert material caused the deterioration of the concrete examined. M.V.K.

Fusing aluminous cement with Portland cement. KATSUZO KOYANAGI. *Jour. Soc. Chem. Ind.* [Japan], **33** [7], 817–22 (1930); for abstract see *Ceram. Abs.*, **10** [2], 96 (1931). S.K.

Petrographic study of alumina cement. KATSUZO KOYANAGI. *Jour. Soc. Chem. Ind.* [Japan], **33** [9], 1018–24 (1930); for abstract see *Ceram. Abs.*, **10** [5], 327 (1931). S.K.

Effect of fineness of cement upon concrete. ERNEST RISSEL. *Zement*, **19** [46], 1079–80 (1930); *Rock Prod.*, **34** [14], 85 (1931).—Water permeability of concrete reacts more to fineness than does compressive strength. A table of results is given. W.W.M.

Anhydrite cement and its constitution. P. P. BUDNIKOFF. *Rev. mat. constr. trav. pub.*, No. 253, pp. 394–96 (1930); see also *Ceram. Abs.*, **9** [7], 504 (1930). A.J.M.

Application of filtration method in volumetric analysis, especially in analysis of Portland cement. H. T. BUCHERER AND F. W. MEIER. *Z. anal. Chem.*, **82**, 1–44 (1930); for abstract see *Ceram. Abs.*, **10** [3], 222 (1931). (*B.C.A.*)

Use of water glass for protection of concrete. C. R. PLATZMANN. *Rev. mat. constr. trav. pub.*, No. 254, pp. 453–55 (1930); for abstract see *Ceram. Abs.*, **9** [5], 334 (1930). A.J.M.

PATENT

Making magnesium oxychloride mixture. HIRAM S. LUKENS. U. S. 1,811,799, June 23, 1931. As a new composition of matter, a mixture of magnesium oxide, magnesium chloride, and aggregate in such proportions that the amounts of magnesium oxide and magnesium chloride are within the ratio of one part by weight of magnesium oxide to form about 0.84 to 1.25 parts by weight of $MgCl_26H_2O$, and the ratio of the amount of aggregate to the combined amounts of magnesium oxide and magnesium chloride is such that the amount of water required to produce therefrom a mix of proper consistency for manipulation will not be in excess of that amount which would produce a solution of 16°Bé if the amount of magnesium chloride in the mixture were dissolved therein.

Enamels

Systematic study of sheet-iron cover enamels. A. I. ANDREWS AND D. G. BENNETT. *Jour. Amer. Ceram. Soc.*, **14** [8], 590–602 (1931); see also *Ceram. Abs.*, **9** [8], 620 (1930).

Silica as a factor in enamels. ANON. *Silicate P's & Q's*, Philadelphia Quartz Co.; *Ceram. Ind.*, **17** [1], 59 (1931).—The use of sodium silicate in place of silica and soda ash is discussed. This substitution lowers the fusion temperature of enamels because the reaction of the silicate is quicker than that of free silica. Properties of the enamel are said to be improved by the more complete combination of the silica. The batch weights of two enamels having the same chemical composition, one containing silica and soda ash and the other sodium silicate, are given. An illustration shows buttons of the two fired to the same temperature. The elimination of carbon-dioxide bubbles formed by the reaction of silica and soda ash is obtained by the above substitution. W.W.M.

Control of ground coat draining time. II. H. G. WOLFRAM. *Amer. Enameler*, **4**

[4], 6–9 (1931).—Several ground-coat milling tests are described and illustrated under different conditions and draining time is tabulated. Results are listed showing what must be done to decrease ground-coat draining time. For Part I see *Ceram. Abs.*, **10** [8], 546 (1931). J.D.R.

Correct firing. FRED MCC. BURT. *Ceram. Ind.*, **17** [1], 21–23 (1931).—Firing is the most important single step in enameling. Firing temperatures, heat treatment, furnaces and equipment, and the use of electric heat are discussed. W.W.M.

Firing schedule for sheet-metal enameling. WILHELM LINKE. *Emaillewaren-Ind.*, **8** [22], 169–70 (1931).—Ceramic ware is classified into groups, and the time required for the initial, second, and finishing firing is given for each group. M.V.K.

Practical experience with oil-fired frit kilns. ANON. *Emaillewaren-Ind.*, **8** [23], 177–78; [24], 187 (1931). M.V.K.

Vertical continuous-enameling furnace. ANON. *Ceram. Ind.*, **17** [1], 63 (1931).—A vertical continuous-enameling furnace developed by the Ferro Enamel Corp., Cleveland, is described. It combines small-sized production unit, low cost, and efficiency with small required floor space, and can be gas or oil fired. Its operation is described and the furnace is illustrated. W.W.M.

Equipment for cleaning metal. VI. R. W. MITCHELL. *Metal Cleaning & Finishing*, **3** [6], 463–66 (1931).—A complete discussion of gas heating as applied to cleaning methods is presented. Illustrated. For Part V see *Ceram. Abs.*, **10** [8], 549 (1931). E.J.V.

Pickle-room control for vitreous enameling plants. W. C. LINDEMANN. *Metal Cleaning & Finishing*, **3** [6], 513–14 (1931).—L. outlines the pickling-room control methods followed in the plant of a prominent manufacturer and stresses the importance of proper regulation of plant procedure. E.J.V.

Better smelting by means of modern equipment and efficient records. ANON. *Ceram. Ind.*, **17** [1], 53 (1931).—Costs of handling chemicals and smelting vary from $1^1/_2$¢ per pound to 4¢ per pound above the cost of materials. The importance of modern equipment and efficient records is emphasized. Some ideal production figures which have been obtained are presented. W.W.M.

New metal-treating process reduces time from 90 to 11 minutes. ANON. *Ceram. Ind.*, **17** [1], 47 (1931).—The surface of metals is Bonderized or treated with a chemical which forms crystals of basic iron phosphate on the surface, making it rustproof and absorbent to protective finishes. Many automobile parts, refrigerator panels, office fixtures, and other pieces of hardware are Bonderized at present. The reduction in processing time by Arthur D. Little, Inc., has increased the possibilities of this process. W.W.M.

Oxides in ground enamel and causes of fishscale flaking. L. STUCKERT. *Sprechsaal*, **64** [27], 504–507 (1931).—Different possible reasons for fishscale flaking in enamelware are discussed. It was found that in furnaces for ground enamel containing nickel the sulphides are often formed. The sulphides are obtained by reduction of sulphates with carbon particles or by reducing conditions in the furnaces. In cases where the ground enamel contains cobalt, formation of sulphides is much more difficult and only possible if a large amount of sulphur is present; for this reason cobalt is preferred to nickel oxide. Formation of fishscale flaking may be avoided if the raw materials contain only small amounts of sulphates, if the burning materials contain as little sulphur as possible, and if the furnace is operated under oxidizing conditions. W.M.C.

Current literature on blisters and needle tappings in wet cast-iron enameling. WALTER KERSTAN. *Emaillewaren-Ind.*, **8** [19], 147–48; [20], 153–55; [21], 163–64 (1931); see also *Ceram. Abs.*, **10** [6], 411; [8], 546 (1931). M.V.K.

Formation of enamel bubbles on welded seams. FELIX GOLDMANN. *Emailletech-*

nische Monats-Blätter, **7** [1], 6–8 (1931); for abstract see *Ceram. Abs.*, **9** [12], 1028 (1930). E.J.V.

Tile for filling stations. RALPH P. BROWN. *Ceram. Ind.*, **17** [1], 56–58 (1931).—B. describes the enameled tile and the application of them by the Standard Oil Co. of Ohio as as exterior finish on one of their filling stations in Cleveland. The tile are guaranteed against crazing, cracking, chipping, or spalling for a period of ten years. Advantages are discussed. W.W.M.

BULLETIN

Effect of smelter atmospheres on the quality of enamels for sheet steel. A. I. ANDREWS AND E. A. HERTZELL. Univ. of Ill., Eng. Expt. Sta., *Bull.*, No. 224.—A preliminary study of some of the gases evolved in the smelting of enamels for sheet steel is made and the effect of certain smelter atmospheres on the quality of enamels investigated. The following observations were made in this connection. (1) All the sodium carbonate and sodium nitrate were decomposed during the first 40 minutes of smelting. (2) When the enamel batch contained sodium nitrate the smelter atmosphere showed a higher percentage of oxygen during the first 40 min. than when this constituent was lacking. (3) Reducing atmospheres and the atmospheres containing 96 to 100% nitrogen and 93 to 100% CO_2 in the smelter were not deleterious to the enamels. (4) When enamels smelted in a high sulphur-dioxide atmosphere were fired in air, pockmarks appeared. Blistering also took place on the ground coat. See also *Ceram. Abs.*, **10** [4], 256 (1931). A.A.

PATENTS

Making artificial granite. HOWARD B. TAFT. U. S. 1,814,012, July 14, 1931. In a process of making artificial granite, first charging a quantity of pulverized natural granite into a crucible and raising the temperature to a point above its melting point, pouring the molten mass into molds of desired form and cooling the granite to a point of solidification, placing the granite article formed in the mold within a leer and raising the temperature to a point within the crystallization temperature range of the granite, and then annealing the article for such a period of time, within the crystallization temperature range, as will thoroughly crystallize the structure of the granite article and form a granite of substantially similar physical and visual characteristics to those of the natural mineral.

Preparing metal surfaces to receive permanent coatings. RALPH Z. HOPKINS, ALBERT E. FELLERS, AND OSCAR T. COFFELT. U. S. 1,814,600, July 14, 1931. The method of protecting metal surfaces and preparing them for subsequent permanent coating which includes treating the surface with acid and then applying a solution which neutralizes the acid residue and also leaves on the sheet a substance which will combine with the permanent coating.

Enameling iron. VEREINIGTE CHEM. FAB. KREIDL, HELLER & CO. Ger. 522,472, Nov. 4, 1923. Fe articles, particularly sheet Fe, are provided with a colorless ground-enamel coating free from CoO or NiO, by applying a suitable mixture of readily fusible and difficultly fusible substances in the form of a moist pulp and then heating the article for a short time, so that the difficultly fusible substances do not completely dissolve in the readily fusible substances, with the result that a coarse-grained coating is produced. A suitable mixture contains borax 36.3, feldspar 36.3, quartz 32, soda 6, $NaNO_3$ 6, CaF_2 1.8, and kaolin 10 parts. (*C.A.*)

Glass

Temperature dependence of the dielectric constant of some glasses in the softening range. G. TAMMANN AND W. BOEHME. *Z. anorg. allgem. Chem.*, **197** [1], 1–17 (1931).—The dielectric constant of glasses increases linearly with the temperature to the temperature t_w, at which there is also a break in the volume-temperature and index of refraction-temperature curves. At higher temperatures the dielectric constant increases more rapidly with the temperature. The temperature t_w lies close to t_g, the temperature at which brittleness becomes evident. The dielectric constant-temperature curve can be represented by two straight lines. The slope of the first is less than that of the second. The first represents the glassy state and the second the viscous state. Actually the change in dE/dT in the softening range is not discontinuous but dE/dT increases more rapidly at first so that the curve shows a transition point. The temperature t_w cannot be determined directly but only by producing the two lines until they intersect. This transition point occurs at the same temperature at which other curves, *e.g.*, the volume-temperature, the C_p^- temperature, and the index of refraction-temperature curves show breaks. The dielectric constant times the field strength equals the total polarization, which consists of a displacement of the charge in the atoms and molecules in the field. A distinction must be made between the polarization which is due to atoms and that due to molecules. In the glassy state the molecules are rigid so that the dielectric constant does not depend on molecular polarization. On the softening of a glass there may be a molecular polarization so that the dielectric constant must increase more rapidly than before. It can be seen that the physical properties of a glass, which depend on the temperature, must undergo similar changes in the softening interval; the curves representing the changes will not be discontinuous but will change slope in the softening interval. As mentioned above, the dielectric constant-temperature curve can be considered as consisting of two parts, one representing the glassy and the other the viscous state. The difference between the slopes of these two parts divided by the slope representing the glassy state is of the same order for all the curves of the various properties which show a break at this point (volume-temperature, index-temperature, *C*-temperature curves) for each glass. This can be considered as proof that the changes of the properties when the molecules are shoved apart are almost proportional to the volume change per degree. This is based on the assumption that the molecules are in irregular arrangement in a glass and so close to one another that they are in contact. In Jena optical glass the dielectric constant increases linearly with the temperature to about 300 °C; in mirror glass this linear increase is only to about 200 °C. At higher temperatures there is an increase in the slope of the curve so that from 300 to 600 °C the dielectric constant has doubled. The dielectric constant-temperature curves for the various glasses are not parallel but intersect. In lead glasses there is a relation between the dielectric constant and the PbO content. L.T.B.

Electrochemistry applied to glass. I. ALEXANDER SILVERMAN. *Trans. Amer. Electrochem. Soc.*, **59**, 183–91 (1931); for abstract see *Ceram. Abs.*, **10** [7], 488 (1931). **II.** *Amer. Glass Rev.*, **50** [33], 13–14 (1931).—In 1910 Heydweiller and Kupferman found that various metals used as electrodes entered glass and accumulated in a colloidal state. Kraus and Darby observed in 1922 that metals displaced sodium better from fused salts than from amalgams. Conductivity measurements show that at 278 °C 74.4% of the sodium in glass conducted and at 343 °C, 81.4%. On further heating, gas was evolved and the glass became discolored. In 1926 H. Hurter (see *Ceram. Abs.*, **7** [1], 21 (1928)) placed a 50-watt metal filament lamp bulb in fused sodium nitrate and potassium nitrate, respectively. From the silver deposited in the voltameter and the increase in weight of the bulb, due to introduction of sodium or potassium from the fused nitrate, H. obtained 22.95 as the atomic weight for sodium and 39.38 for potas-

sium. F. Quittner (see *Ceram. Abs.*, **7** [10], 675 (1928)) immersed thin-wall flasks of Thuringian and Schott 1447" ' glass, filled with standard base and alkali-sulphate solutions in the same solutions and electrolyzed through the glasses. The solutions were titrated for alkali and acid, respectively, and it was found that migration of ions into the glass increased with concentration and for normal sodium sulphate, the sodium ion entering the glass approximated Faraday's law. G. Gehlhoff and M. Thomas, in an article on "The Electrical Conductivity of Glass" (see *Ceram. Abs.*, **5** [6], 178 (1926)), reported efforts to correlate composition and insulating power on the basis of the conductivity. They listed the decreasing insulating value of the various oxides as follows: CaO, B_2O_3, BaO, Fe_2O_3, PbO, MgO, ZnO, SiO_2, Al_2O_3, K_2O, Na_2O. E.P.R.

Permeability of glasses to ultra-violet radiation. I. P. GILARD, P. SWINGS, AND A. HAUTOT. *Rev. belge ind. verrières*, **2**, 2–10 (1931).—Ultra-violet radiation, history of ultra-violet transmitting glasses, and compositions of ultra-violet glasses are among the topics discussed. **II.** *Ibid.*, **2**, 26–30 (1931).—The authors discuss in detail the experimental methods used for measuring the ultra-violet absorption of glasses. See also *Ceram. Abs.*, **9** [9], 726 (1930). A.J.M.

Invisible ray glasses. S. ENGLISH. *Glass*, **8** [2], 52–57 (1931); for abstract see *Ceram. Abs.*, **10** [5], 338 (1931). H.W.A.

Making ultra-violet ray transmitting glass by automatic machines. ANON. *Nat. Glass Budget*, **47** [10], 5 (1931).—Vita glass is manufactured by a completely automatic process, a variation of the Fourcault system which permits drawing large continuous sheets. E.P.R.

An investigation of the flow of glass in tank furnaces by the use of barium oxide. E. J. C. BOWMAKER AND J. D. CAUWOOD. Presented at meeting of Soc. Glass Tech., June 17, 1931.—In view of the disadvantages attaching to the use of any deep-blue coloration or black specks in the investigation of the flow of glass through a tank furnace, the authors decided to employ barium carbonate as the substance to be fed into the tank and traced through to the machines. The barium carbonate was introduced into the batch so that 0.5% BaO should replace 0.5% CaO in the glass of the approximate percentage composition, SiO_2 74, CaO 9, R_2O_3 0.6, B_2O_3 0.4, Na_2O 16. No effect of the barium oxide upon the working of the glass was noticed and no trace of cordy metal was produced. Hourly samples of glass were collected. The barium oxide contents of the samples were determined and shown in tables and graphs. Initial appearance of barium at the machines occurred between 9 and 10 hr. after first filling on, and the maximum BaO content was only 20% of the theoretical, indicating the existence of fast-moving and powerful mixing currents. The position of a machine was a more important factor than its "pull." Position in relation to the furnace center line was the important factor.

Density of sodium metasilicate-silica glasses. F. WINKS AND W. E. S. TURNER. Presented at meeting of Soc. Glass Tech., June 17, 1931. The preparation of specially pure glasses of the simple soda-silica series is described, the meltings having been made in platinum. The densities of the glasses were determined with great care and the results are presented in graphical form. The curve obtained for the specific volumes of the glasses shows no break at a composition of 66% SiO_2. Extrapolation from this curve yields a value of 2.19 for the density of vitreous silica itself, the directly determined value being 2.20. Over the range of compositions from 67 to 91% SiO_2, *i.e.*, including most commercial simple glasses, the density factor for soda (Na_2O) is found to be 3.46, as against the value 3.47 previously obtained by S. English and W. E. S. Turner.

Thermoöptical properties of glasses rich in silica. F. RINNE. *Keram. Rund.*, **37**, 772 (1929); *Jour. Soc. Glass Tech.*, **13**, 371*A* (1929).—The n's of glassy substances were determined for wave lengths of 735 to 440$\mu\mu$ for temperatures between −160° and 1000°. The following substances were used: (*a*) fused quartz, (*b*) hyalite (SiO_2,

3.4% H_2O), (*c*) hyalite (SiO_2, 4.84% H_2O), (*d*) opal (SiO_2, 8.5% H_2O), and (*e*) opal (SiO_2 9.73% H_2O). As the water content increased, the n was lowered. The dispersion was constant. A maximum was detected in the n-temperature curve at 0° with glass (*e*). No separation of water could be detected in an opal on cooling in liquid air. (*C.A.*)

Development of zirconium glass with the help of the Straubel sun mirror. W. M. COHN. *Ber. deut. keram. Ges.*, **12** [3], 118 (1931).—During former experiments, a mixture of zirconium oxide and magnesium oxide was heated for a long time up to 1900 to 2000°. It contained the A_2 modification of ZrO_2 and a combination of ZrO_2 and MgO of cubic structure. This material was heated up to a melting temperature of more than 3000°C in an oxidizing atmosphere, and a zirconium glass developed. The temperature could be reached with the help of the Straubel reflecting mirror and the sun energy. The apparatus is described. When devitrified, the zirconium glass contains the *B* modification of zirconium which corresponds to the cristobalite modification of SiO_2. I.R.

Fluorides as opacifiers of glasses. O. KNAPP. *Sprechsaal*, **64** [25], 468–70 (1931).—X-ray investigations of different authors have shown that sodium and calcium fluorides have an opacifying effect when present in glasses. Some graphs and tables are given which enable the manufacturer to produce the desired glass and in this way avoid the use of empirical data. W.M.C.

Borax in the glass industry. ANON. *Rev. belge ind. verrières*, **2**, 35–37 (1931). A.J.M.

Synthesis of glass. F. FRANCESCHINI. *Ind. Silicati*, **9** [2], 7–10; [3], 7–10 (1931).—F. reviews (1) the work of E. Zschimmer (Theory of the Art of the Fusion of Glass, Vol. 2) on the laws for calculating silica-sodium-lime glass of good and medium chemical resistance; the laws for fixing the alkali content in relation to the lead content of lead glasses; the calculation of the constants of glass in the form of single functions of the oxides in determining fundamental glasses; (2) the work of G. Gehlhoff and M. Thomas on "Physical properties of glasses in dependence on their chemical constitution" (see *Ceram. Abs.*, **8** [8], 566 (1929)); and (3) the work of Turner, Wilhelm, Schmidt, Kühl, and Dingler on related subjects. See also *Ceram. Abs.*, **10** [4], 257 (1931). M.V.K.

Chemical resistance of glass. F. FRANCESCHINI. *Ind. Silicati*, **9** [1], 7–10 (1931).—Methods and processes for determining the chemical resistance of glasses are described: (1) A quick boiling test proposed by F. Friedrich for poor glass of low resistance; (2) HCl test or Weber test, for the sensitiveness of glasses; (3) iodo-eosin method of F. Mylius; (4) F. Mylius test by extraction at 80°C; (5) determination of the alkalinity of solutions in ground or powdered glass by Ernest Fischer and Walter Tepohl; (6) test for optical glass by Hermann Heinrichs and Walter Tepohl; (7) test on the chemical resistance of glass by Keppeler; and (8) the Violet Dimbleby and W. E. S. Turner test. M.V.K.

Résumé of a course in glassmaking. IX. ANON. *Rev. belge ind. verrières*, **2**, 11–12 (1931).—Fining agents (arsenic, sodium nitrate, and potassium nitrate) and decolorizers are discussed. **X.** *Ibid.*, **2**, 37–39 (1931).—Carbon, sulphur, antimony, the rare earths, compounds of chromium, copper, cobalt, nickel, selenium, silver, gold, and uranium are discussed. For Part VIII see *Ceram. Abs.*, **10** [6], 415 (1931). A.J.M.

Suggestions in connection with glass fining. ANON. *Ceram. Ind.*, **17** [1], 51–53 (1931).—This article is a discussion pointing out some interesting suggestions about the formation and elimination of gas from the molten glass batch. W.W.M.

Making compound glass. H. SCHMIDT. *Sprechsaal*, **64** [19], 355–56 (1931).—The different procedures for making the so-called compound glass are described. A new process was developed which consists of placing alternate layers of soft glass and celluloid in a container, exhausting the air from the container, and using compressed air to force the layers together. W.M.C.

Glass from blast-furnace slag. C. A. BASORE. *Nat. Glass Budget*, **47** [5], 18 (1931); *Pit & Quarry*, **22** [4], 28 (1931); *Amer. Glass Rev.*, **50** [33], 16 (1931); for abstract see *Ceram. Abs.*, **10** [8], 557 (1931). E.P.R.

Ceramic glass. W. FUNK. *Naturwissenschaften*, **19** [13], 290–92 (1931).—Composition, temperature of melting, color, etc., are reviewed. L.T.B.

Glass and its development. WILLIAM PICKETT HELM. *Nat. Glass Budget*, **47** [5], 19 (1931).—H. describes the advancement of glassmaking from the time of William Penn to the present day. A brief discussion of general glass manufacture is given. See also *Ceram. Abs.*, **10** [7], 494 (1931). E.P.R.

Surface leakage of "Pyrex" glass. W. A. YAGER AND S. O. MORGAN. *Jour. Phys. Chem.*, **35** [7], 2026–42 (1931).—A method of measuring surface leakage of glass at various humidities is described and the nature of surface leakage is discussed. The surface conductivity, surface capacity, and power factor depend upon the thickness of the surface film, which in turn depends upon the relative humidity. The surface conductivity and power factor further depend upon the volume conductivity of the surface film. The conductance was found to increase with increasing frequency whereas the capacity and power factor decreased. The increase in power factor with relative humidity is least at high frequencies. The surface conductivity and capacity were found to depend upon frequency. G.R.S.

Corrosion of tank blocks by opal glasses. C. J. UHRMANN AND S. M. SLATER. *Pottery Gaz.*, **56** [645], 408 (1931); see also *Ceram. Abs.*, **10** [1], 27 (1931). E.J.V.

Dimensional changes in glass resulting from heating cycles. A. Q. TOOL, D. B. LLOYD, AND G. E. MERRITT. *Fuels & Fur.*, **8** [9], 1258 (1930); see also *Ceram. Abs.*, **10** [1], 24 (1931). A.E.R.W.

Meaning and wrong use of the expression "hard glass." P. H. PRAUSNITZ. *Sprechsaal*, **64** [22], 413–17 (1931).—P. points out that the expression "hard glass" is used frequently in a wrong way. He proposes to use this expression only for glasses which have internal strain either by rapid cooling or by combinations of glasses with different coefficients of expansion. W.M.C.

Chemicals and the mirror. CARL W. BACKUS. *Amer. Glass Rev.*, **50** [33], 27–28 (1931).—Many new types of mirrors such as the subdued Galena-blue, the gold mirror, and the two- and three-tone mirrors, offer more adaptable surfaces for the designer to draw upon in creating artistic effects. Much of the responsibility for the chemical control of the process has now been assumed by the chemical manufacturer. Silver nitrate is produced from the purest materials which are repeatedly recrystallized until tests show the absence of harmful impurities. Gold chloride crystals are made to contain a certain amount of HCl which, if not controlled, can be the source of great trouble. E.P.R.

Glass silk for heat insulations. ANON. *Engineering*, **131** [3408], 613 (1931).—The heat-insulating properties of glass can be efficiently utilized in the form of fibers or silk between which large volumes of air are occluded. The fibers can be prepared by drawing molten glass over the surface of a revolving drum so that it is rapidly cooled. The manufacture of this material at the Glasgow factory of Chance Brothers & Co., Ltd., Birmingham, is described. A.A.

Studies of defective glasses. FRANZ HUNDESHAGEN. *Glastech. Ber.*, **8** [9], 530–39 (1930); **9** [1], 35–49 (1931).—Defective glasses were classified into the following categories: (1) glasses with an excess of alkalis and a deficiency of lime or lead oxide, etc., (2) glasses with an excess of lime or lead oxide, etc., and a deficiency in alkalis, (3) glasses with an excess of bases and a deficiency in silica, (4) glasses with an excess of silica and a deficiency in bases, (5) glasses with a troublesome content of chlorides or sulphates, (6) glasses with a troublesome content of sulphides or polysulphides, (7) glasses with a

troublesome content of phosphates or arsenates, etc., (8) glasses with discolorations due to a deficiency in the oxidizing addition or due to the improper use of decolorizers or coloring additions, (9) glasses with nodules of unvitrified, or streaks and drops of incompletely dissolved batch components, (10) glasses with nonuniform coloring, discolorations, gas bubbles, etc., (11) glasses with nodes of fragments, or streaks and drops of molten refractory materials, (12) glasses with metallic impurities which come in through the working of the glass or are produced by the reducing effects of the furnace gases on the melts, (13) glasses which are injured through reducing or oxidizing effects during the working, (14) glasses which suffer due to the kind of heating, too high a temperature, and length of heating during working, (15) glasses with defects which can be traced to the cooling process, and (16) glasses with a decided tendency to spontaneous breaking or to fault development, in spite of normally proceeding cooling. The studies were conducted on examples of these various categories and each is discussed in detail. Illustrated. E.J.V.

Extract of literature on defects in glasses, their detection and prevention. R. SCHULTZE. *Glastech. Ber.*, **9** [1], 47–49 (1931). E.J.V.

Chemical causes of the coloring of silicate and quartz glasses by radium radiation. JOSEF HOFFMANN. *Z. anorg. allgem. Chem.*, **197** [1], 29–51 (1931); for abstract see *Ceram. Abs.*, **10** [8], 556 (1931). For a study of Mn and Fe in glasses see article by Salaquarda, *Ceram. Abs.*, **10** [7], 489 (1931). L.T.B.

Black-colored glasses. ANON. *Sprechsaal*, **64** [21], 394–95 (1931).—A review of the manufacture of black glass is given with some advice for the betterment of the melt. This type of glass attacks the crucible badly. To reduce this action a melt of soft glass is run between melts of the black glass. W.M.C.

Production of salmon-red glass. ANON. *Sprechsaal*, **64** [23], 430–31 (1931).—Different batch compositions of glasses having a salmon-red color are given and the making of these glasses is discussed. W.M.C.

Discoloration or fading of glasses and materials which resemble glass by β- and γ-rays. JOSEF HOFFMANN. *Glastech. Ber.*, **8** [8], 482–89 (1930).—The original article appears in this issue of *Glastech. Ber.* For abstract see *Ceram. Abs.*, **10** [2], 104 (1931). E.J.V.

Note on the measurement of temperatures of gases in a glassmelting furnace. J. H. PARTRIDGE AND A. C. JEFFKINS. Presented at meeting of Soc. Glass Tech., June 17, 1931.—In the experiments described, the temperature readings of a simple form of suction pyrometer and of an ordinary thermocouple are compared when the instruments are placed at the base of and immediately above the checkerwork of the regenerator. The authors conclude that the suction pyrometer gives more accurate readings than the ordinary type at the base of the regenerator, but that there is little difference in efficiency of the two instruments at lower temperatures, such as those of the waste gases entering the gas regenerator. Further measurements, however, are to be carried out. Chromel-eureka couples give better service than chromel-alumel wire couples. An improved type of suction pyrometer has been constructed.

Illuminating gas for heating glass furnaces. F. GOVENS. *Rev. belge ind. verrières*, **2**, 34 (1931). A.J.M.

Utilization of waste heat from industrial furnaces. A. F. SMULDERS, LTD. *Glass*, **8** [4], 140–45 (1931).—The heat-recuperating cycle would constitute a theoretically perfect cycle if the product of the weight and of the specific heat of the combustible fluids is equal to the product of the same factors in the fluid resulting from the combustion. This is never fulfilled in furnaces. The principles of the A. F. S. Ljungstrom recuperating sets for steam production are given in detail. The same principles hold true for glass furnaces. H.W.A.

Charging of glass tanks in the Fourcault process. G. NOVÁKY. *Sprechsaal*, **64** [26], 486–87 (1931).—The importance of a consistent height of glass in the tank is pointed out and a device is shown by means of which a signal is given as soon as the height of the melt is lowered too much. Thus it is possible to charge the tank with only the amount of batch which is actually used in the machines. W.M.C.

Flexible heating unit for glass leers. GENERAL ELECTRIC CO. *Glass Ind.*, **12** [7], 153 (1931).—The new electric heating unit for glass-annealing leers is designed to provide low initial and maintenance costs, correct heat distribution throughout width and length of the leer, flexibility of arrangement of the units in the leer, ease of removal or replacement in either floor or roof, and constant resistance and simplicity of terminal arrangement. A detailed description is given. Illustrated. E.J.V.

Manufacture of rolled plate. X. ERNST LUTZ. *Glass Ind.*, **12** [7], 144–49 (1931).—A description of the use of a cutting table in conjunction with a leer is explained with the aid of a detailed drawing of the apparatus. The layout, equipment, and operations used in the grinding and polishing shop are taken up. The care necessary in the polishing operation is stressed. For Part IX see *Ceram. Abs.*, **10** [8], 557 (1931). E.J.V.

Twenty years of glassmaking. S. R. SCHOLES. *Glass Ind.*, **12** [7], 141–42 (1931).—A review is made of all the changes that have taken place in the science of glassmaking in the past twenty years, starting with the raw materials, the new colorants and decolorizers, mixing room equipment and methods, refractories, fuels, and developments in the various types of glass now being produced, as well as in the annealing and finishing processes. E.J.V.

Glass for indicators on high-pressure steam boilers. ANON. *Feuerungstechnik*, **19** [5], 80 (1931). M.V.K.

Glass in schools. JOSEPH D. HARRISON. *Popular Sci.*, **119** [2], 58 (1931).—A design for the future schoolhouse has been developed in which the building is a large circular structure with walls and most of its roof of glass. Interior opaque glass walls would serve as screens for projection of moving pictures. Illustrated. E.J.V.

Ultra-violet glass in hospital. ANON. *Amer. Glass Rev.*, **50** [34], 36 (1931).—Cubicles of health-giving glass will be a feature of the new hospitalization building opened by the Home for Hebrew Infants, New York. Each of the 75 cubicles in the home is made of ultra-violet transmitting glass and resembles a miniature glass chamber. Glass doors open on large balconies constructed so as to be easily accessible. Through the use of the ultra-violet light, under medical supervision, a certain immunity against disease may be built up. E.P.R.

Office building has glass walls. ANON. *Popular Sci.*, **118** [5], 75 (1931).—An office building in Worcester, Mass., having windows set in narrow steel frames and extending from floor to ceiling gives the effect of an almost solid glass wall. Illustrated. E.J.V.

Glass-lined concrete tanks for wine storage. ANON. *Internat. Bull. Refrigeration*, **11**, 328 (1930).—An account is given of the new plant built at Ivry, France, for the Damay establishments. H.H.S.

Making 200-in. quartz mirror. JOHN W. HAMMOND. *Glass Ind.*, **12** [6], 125–27 (1931); for abstract see *Ceram. Abs.*, **10** [7], 490; [8], 534 (1931). E.J.V.

Reports on the joint meetings of Deutschen Glastechnischen Gesellschaft and the Society of Glass Technology. F. SPÄTE, O. BARTSCH, W. FRIEDMANN, AND G. GEHLHOFF. *Glastech. Ber.*, **9** [1], 1–14 (1931); for abstract see *Ceram. Abs.*, **10** [6], 467 (1931). E.J.V.

West Virginia produces about one-half of American stemware. ANON. *Amer. Glass Rev.*, **50** [40], 28 (1931). E.P.R.

Window-glass industry in Belgium. J. KERVYN DE MEERENDRE. *Rev. belge ind. verrières*, **2**, 30–32 (1931).—A historical and statistical review is given. A.J.M.

Depressed condition in Belgian glass industry. ANON. *Commerce Repts.*, No. 13, p. 838 (1931).—In window glass, Czechoslovakia is competing successfully against Belgian manufacturers, and German glass is displacing Belgian window glass in the Netherlands. Stocks are low, the greater part being roofing glass, which is not in great demand. A critical situation exists in the tumbler industry. E.J.V.

History of English glassmaking. W. E. S. TURNER. *Rev. belge ind. verrières*, **2**, 33–34 (1931). A.J.M.

Italian glass market. ANON. *Pottery Gaz.*, **56** [646], 580 (1931); reprinted from *Ind. Silicati*.—The mechanical window-glass industry is well occupied generally, but factories run by hand labor are doing almost nothing. The white and blown glass is in little demand and artistic blown glass is in poor demand. E.J.V.

Japanese glass industry. RICHTER. *Rev. belge ind. verrières*, **1**, 196 (1930). A.J.M.

Polish glass industry. ANON. *Pottery Gaz.*, **56** [646], 580 (1931); reprinted from *Allgemeine Glas-und-Keram-Ind.*—The blame for the scarcity of orders is placed on Russia. Export into Austria is substantially improving. E.J.V.

Rumanian glass industry. ANON. *Pottery Gaz.*, **56** [646], 580 (1931).—The bottle and hollow glass factories have amalgamated. The annual consumption, once 17 to 18 million pieces, is now about 12 million. The St.-Gobain group is now equipped for the production of bottles as well as of flat glass. E.J.V.

BOOK

Glass, Its Preparation and Use. F. H. ZSCHACKE. Reviewed in *Rev. belge ind. verrières*, **1**, 200 (1930); see also *Ceram. Abs.*, **10** [5], 343 (1931). A.J.M.

PATENTS

Producing sheet glass. JOHN L. DRAKE. U. S. 1,810,908, June 23, 1931. In combination, in apparatus for producing sheet glass, an inclined receiver, a pair of sheet-forming rolls arranged at one end of the receiver, an elongated receptacle containing a mass of molten glass and adapted, when tilted, to deliver the glass upon the receiver in stream form, one side wall of the receiver being provided with an upstanding lip at substantially the longitudinal center thereof so that when the receptacle is tilted the glass will flow therefrom first adjacent its opposite ends and subsequently from the center over the lip.

Glassmelting furnace and process for producing molten glass. ENOCH T. FERNGREN. U. S. 1,810,911, June 23, 1931. In a tank furnace containing molten glass, a rotatable member, means for cooling the member, means for raising and lowering the member relative to the molten glass, means preventing the member from drifting longitudinally of the furnace, means for rotating the member to impart a backward-flow movement upon the surface of the molten glass, the surface of the member being so shaped to cause the backward-moving surface glass to creep toward the side walls of the furnace, and means for removing the backward-moving glass from the tank furnace.

Sheet-glass flowing apparatus. LEOPOLD MAMBOURG. U. S. 1,810,921, June 23, 1931. In sheet-glass apparatus, a furnace containing a mass of molten glass and having an outlet at one end thereof, a table arranged in a lower horizontal plane than the outlet end of the furnace and adapted to receive the molten glass therefrom, the table having an overflow lip at one end, a trough arranged below the overflow lip of the table and adapted to receive the molten glass therefrom, the trough comprising a plurality of closely associated pipes constituting the side walls thereof, means for circulating a temperature-control medium through the pipes, means for maintaining the glass at a constantly high temperature from the furnace to the trough, the glass flowing from the

trough in stream form, and means for absorbing heat from the stream as it leaves the trough to form a sheet.

Sheet-glass apparatus. INGVALD O. PEDERSEN. U. S. 1,810,927, June 23, 1931. In sheet-glass apparatus, a continuous tank furnace for supplying a stream of molten glass to sheet-forming means, including a bowed lower front wall and a flow block for retarding the flow movement of the central portion of the stream more than the border portions as the stream flows from the tank.

Apparatus for use in the manufacture of laminated glass. GEORGE B. WATKINS. U. S. 1,810,934, June 23, 1931. Means for holding a plurality of superposed sheets of material to be joined against relative movement with respect to one another during such joining, including a frame for receiving the assembled sheets therein and means carried by the frame and adapted to engage the edges of the sheets.

Forming sheet glass. WILLIAM E. NOBBE. U. S. 1,810,980, June 23, 1931. The method of forming sheet glass which consists in drawing a plurality of streams of molten glass upwardly from a molten bath, uniting the streams at their upper end while they are still in a substantially vertical position to form a single sheet, and in continuously forcing glass upwardly into the stream sources under hydrostatic pressure.

Sheet-glass surfacing apparatus. JOHN L. DRAKE. U. S. 1,811,044, June 23, 1931. In glass-surfacing apparatus, a horizontal supporting member rotatable about a substantially vertical axis and a plurality of polishing members carried by the supporting member, each polishing member including a vertical spindle projecting upwardly through the supporting member and slidably keyed thereto, a compression spring encircling the spindle above the supporting member, a plurality of vertical pins supported by the polishing member and received within pockets formed in the underside of the supporting member, and compression springs encircling the pins within the pockets.

Shaping glass. ROBERT W. CANFIELD. U. S. 1,811,075, June 23, 1931. In glassware-forming apparatus, a mold, a suction head coacting with the mold, means therein for withdrawing air from the mold through a plurality of openings and means for substantially instantaneously varying the total size of the openings in response to variations in the level of the glass within the mold.

Drawing sheet glass. HOWARD L. HALBACH. U. S. 1,811,125, June 23, 1931. The combination, with apparatus for drawing a glass sheet continuously from a body of molten glass, of a hollow metal cooler extending transversely of the bath adjacent the bath and the glass sheet and having a pair of opposing vertical faces with the face next to the face of the sheet substantially parallel thereto, and provided opposite the marginal portions of the sheet with enlargements whose faces also lie parallel to the sheet and closer to the sheet than does the face of the cooler intermediate the enlargements, and means for circulating a cooling liquid through the cooler.

Cutting designs in glass. PARKER H. JAMES AND HARRY C. WOODSMALL. U. S. 1,812,485, June 30, 1931. For cutting designs on glass, the combination of a frame, a table maintained on the frame in fixed vertical relation thereto but adapted to be moved in a horizontal plane thereover, a shaft below the table and projecting at one end beyond the side of the table, a grinding wheel on the end of the shaft, and means for adjusting the shaft in a vertical plane and maintaining the shaft in that plane to permit the cutting edge of the wheel to be raised and lowered in relation to the top of the table, glass-elevating means along an edge of the table, power means for reciprocating the table past the wheel, and hand means for reciprocating the table independently of the power means.

Feeding molten glass. FRED E. JEWETT. U. S. 1,812,534, June 30, 1931. The combination of a source of molten glass, a covered flow spout communicating therewith and having a submerged outlet near its outer end, a refractory tube having an external diameter in excess of the submerged outlet, arranged vertically above the outlet with its

lower end submerged in the molten glass, means by which the tube may be vertically adjusted, means by which alternate plus and minus air pressures may be established within the upper end of the tube, means by which heat may be applied locally to the surface of the glass around the tube, and means by which the delivery of fluid fuel to the local heating means may be controlled, the means comprising a thermocouple projected into the flow spout closely adjacent the surface of the glass therein at a point between the source of supply and the submerged orifice, and a baffle projected into the flow spout above the surface of the glass between the thermocouple and the local heating means.

Production of glass in strip form. ERNEST BRISTOW LE MARE. U. S. 1,812,537, June 30, 1931. Process of gradually reducing the speed of a hot glass strip traveling on a roller bed by turning some of the rollers supporting the strip in a forward direction and others in a backward direction.

Pressing glassware. THEODORE H. SLOAN. U. S. 1,812,564, June 30, 1931. Method of manufacturing finished pressed glassware, consisting of providing between coöperating mold and plunger members of a glass press an article-forming cavity as thick throughout its main body as at and adjacent to its edge, placing in the center of the mold a body of molten glass of less volume than the article-forming cavity, and forming from the glass an article having a central base portion and a body portion extending upwardly therefrom and as thick throughout its body portion as at and adjacent to its edge, solely by pressing the glass between the press members and thereby causing it to flow toward but not to the outer boundary of the body-forming portion of the cavity, and to chill with a permanent convexly rounded and completely finished edge.

Free-pressing glassware having irregular edges. THEODORE H. SLOAN. U. S. 1,812,565, June 30, 1931. Method of manufacturing finished pressed glassware having an irregular edge, consisting of forming between plunger and mold members of a glass press a mold cavity of different thicknesses along different lines of flow of glass between the members, placing in the center of the press mold a body of molten glass of less volume than the article-forming cavity between the mold and plunger, and forming an article from the glass solely by pressing the glass between the members and thereby causing it to flow toward but not to the outer boundary of the cavity and to chill with a permanent convexly rounded and completely finished edge, the glass flowing farther along the thicker paths of flow in the cavity to form the edge irregular in its longitudinal extent.

Producing sheet glass. LUKE C. MAMBOURG. U. S. 1,812,599, June 30, 1931. In sheet-glass apparatus, a receptacle containing a mass of molten glass, a pair of rotatable rolls mounted thereover and arranged to create a sheet-forming pass, and a pair of non-metallic refractory members arranged within the molten glass contained in the receptacle, one of the members being positioned under the rolls at one side of the receptacle and the other of the members being placed in a similar position at the opposite side of the receptacle, the refractory members being provided for controlling the movement of glass toward the ends of the sheet-forming pass between the rolls.

Glassmelting apparatus. WILLIAM A. MORTON. U. S. 1,812,975, July 7, 1931. Glassmelting apparatus comprising a hearth shaped to accelerate the glass flow, and burners arranged to produce a flame stream flowing in the reverse direction to the glass flow.

Glassforming roll. LOUIS BOUDIN. U. S. 1,813,142, July 7, 1931. The combination with a roll having trunnions upon the ends thereof and having an interior cavity of substantially uniform diameter from the outer end of one trunnion to adjacent the opposite end of the roll, an induction member having a conical end in the last-named end of the roll, and a cylindrical core within the roll having a conical head adjacent to the induction member and spacing members adapted to center the core within the roll.

Glass-surfacing machine. WILLIAM H. MARR. U. S. 1,813,412, July 7, 1931. A

sheet-glass surfacing machine comprising a horizontally disposed circular work table rotatable on its vertical axis and provided at its center with an elevated portion extending over a central inactive zone, the raised portion being adapted to aid in anchoring glass to the table and in avoiding the collection of abrasive material in the center of the table, the remainder of the surface of the table forming a support for glass, a plurality of rotatable circular runners of equal diameter positioned above the table and each extending from its periphery to the inactive zone, and means for rotating the table, the runners being rotated by frictional contact with the glass mounted upon the rotating table.

Feeding molten glass. GEORGE E. HOWARD. U. S. 1,813,742, July 7, 1931. Glass-feeding apparatus comprising a receptacle for molten glass having a discharge opening in its bottom, a vertical plunger mounted for vertical reciprocation above the opening, means for lifting the plunger and then permitting the plunger to fall toward the opening independently of the lifting means, and means independent of the glass and of the lifting means for varying the speed at which the plunger will fall toward the opening.

Glass. CHARLES EDWIN GOULD, WILFRED MARSH HAMPTON, AND HAROLD SHARPE MARTIN. U. S. 1,814,507, July 14, 1931. A batch for making glass especially transparent to ultra-violet radiation of wave lengths below 3200 A.U. consisting of silica 560 parts, borax 527 parts, and powdered metallic zinc 8 parts.

Forming sheet or plate glass. JOHN L. DRAKE. U. S. 1,814,905, July 14, 1931. In sheet-glass apparatus, a receptacle containing a mass of molten glass, a plurality of pairs of superimposed rotatable members arranged above the mass of molten glass, the rotatable members of the upper pair coöperating with the rotatable members of the lower pair to form a substantially closed pocket between their coacting peripheries, and means for rotating the rotatable members in a manner to feed a supply of molten glass upwardly into the pocket wherein it is maintained under pressure and then reduced to sheet form.

Drawing, cutting, gripping, and conveying sheet plate glass. CHARLES J. JORDAN. U. S. 1,814,932, July 14, 1931. The combination with a plurality of glass-extruding outlets, of a supporting guide immediately under the plurality of outlets, the supporting guide having transverse abutments, a cutting frame in the supporting guide provided with transverse cutting knives between the cutting edges of which and the abutments the extruded glass passes, and pneumatic means operatively associated with the cutter frame for severing the glass.

Glass manufacture. T. F. PEARSON. Brit. 321,195, Dec. 27, 1929; Ger. 522,500, April 25, 1929. A feeder of the reciprocating-plunger type has the outlet orifice surrounded by a cylindrical sleeve or baffle which extends upward beyond the level of the glass but is open to the hot gases, and an opening controlled by a gate is provided in the side of the sleeve remote from the body of the furnace. The amount of glass flowing through the orifice is regulated by the gate which can either be raised to any desired position or can be reciprocated in unison with the plunger.

Nonsplintering glass. C. H. FIELD AND D. HASLETT. Brit. 348,723, May 28, 1931.

Manufacture of glass tubes and rods. J. R. C. JORGENSON. Brit. 348,857, May 28, 1931.

Leers for annealing glassware. UNITED GLASS BOTTLE MFRS., LTD., AND T. C. MOORSHEAD. Brit. 348,872, May 28, 1931.

Heat-resisting glasses giving daylight effect. CORNING GLASS WORKS. Brit. 348,911, May 28, 1931.

Manufacture of colored electric light bulbs. IMPERIAL CHEMICAL INDUSTRIES, LTD., AND E. A. BEVAN. Brit. 349,160, June 4, 1931.

Manufacture of splinterless glass. I. G. FARBENINDUSTRIE AKT.-GES. Brit. 349,283, June 4, 1931.

Manufacture of glass tubes and automatic apparatus embodying them. L. SANCHEZ-VELLO. Brit. 349,315, June 4, 1931.

Feeding glass sheets from the forming machine to the leers. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Brit. 349,844, June 10, 1931; see also *Ceram. Abs.*, **10** [8], 566 (1931).

Grinding or polishing sheet glass. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Brit. 349,928, June 17, 1931.

Reheating or cooling glass in sheets or slabs. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Brit. 350,422, June 24, 1931.

Conduits for use in the production of glass. PILKINGTON BROS., LTD., AND E. B. LE MARE. Brit. 350,480, June 24, 1931.

Machine for operating on bottles. A. M. JORGENSEN. Brit. 350,724, June 24, 1931.

"Pushing" glass bottles. SOC. ANON. D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Brit. 350,827, June 24, 1931.

Electric furnaces and methods for making glass, etc. J. K. B. RAEDER. Brit. 350,930, July 1, 1931.

Continuous glass grinding and polishing machines. PILKINGTON BROS., LTD., AND J. H. GRIFFIN. Brit. 351,047, July 1, 1931.

Manufacture of unsplinterable glass. A. V. JOHNSON. Brit. 351,257, July 1, 1931.

Glass furnaces. UNITED GLASS BOTTLE MFRS., LTD., T. C. MOORSHEAD, AND F. A. HURLBUT. Brit. 351,636, July 8, 1931.

Street-lighting glassware. HOLOPHANE, LTD., AND S. ENGLISH. Brit. 351,761, July 8, 1931.

Glass-bending furnaces. J. ZINGG. Brit. 351,862, July 8, 1931.

Glassmaking. ERNST HILGERS. Fr. 697,418, June 14, 1930. Apparatus for rolling plates of glass is described. (*C.A.*)

Glass. CORNING GLASS WORKS. Fr. 697,570, June 17, 1930. Glass which has been frosted, *e.g.*, electric bulbs, is prevented from "aging" by washing it in an aqueous solution of AlF_3. (*C.A.*)

Cooling furnace for sheets of glass. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Fr. 697,839, June 24, 1930. (*C.A.*)

Melting glass. GUSTAV KEPPELER. Fr. 697,844, June 24, 1930. In melting glass the mixture containing finely divided SiO_2, sweated in known manner, is submitted to a brisk elevation of temperature so that heaping of the fusion flux is not possible and the sweating material, before melting, remains as completely as possible in the action of the flame. (*C.A.*)

Method and plant for making sheet glass with wire insertions. HERMANN MÜLLENSIEFEN. Ger. 522,087, July 19, 1928. (*C.A.*)

Roll-conveyer leer for intermittently prepared sheet glass. NAAMLOOZE VENNOOTSCHAP MIJ. TOT BEHEER EN EXPLOITATIE VAN OCTROOIEN. Ger. 522,205, June 26, 1929; see also *Ceram Abs.*, **10** [8], 567 (1931). (*C.A.*)

Roller apparatus for conveying intermittently prepared sheet glass to the leer. SOC. ANON. DES MANUFACTURES DES GLACES ET PRODUITS CHIMIQUES DE ST.-GOBAIN, CHAUNY, ET CIREY. Ger. 522,416, Oct. 14, 1927. (*C.A.*)

Making glass articles showing marbled or veined effects. JENAER GLASWERK SCHOTT & GEN. Ger. 522,417, Dec. 4, 1928. (*C.A.*)

Paddle mechanism for circulating molten glass. JOHN MONCRIEFF, LTD., AND ALEXANDER F. MCNISH. Ger. 522,499, Feb. 15, 1929; for patent see *Ceram. Abs.*, **9** [2], 102 (1930). (*C.A.*)

Structural Clay Products

Misuse of barium carbonate. ANON. *Brit. Clayworker*, **40** [469], 51 (1931).—The value of barium carbonate as a means for preventing "scum" or efflorescence, due to soluble sulphates in some clays, is well known, but little has been written about the defects produced by the misuse of this material. In the first place, the barium carbonate should be in the state of the finest possible powder. The coarse grains of ground witherite are unsuitable and only precipitated barium carbonate should be used. The barium carbonate must be well mixed with the clay. If irregularly distributed, it will form white spots on the surface of the goods. An excess of barium carbonate may cause discoloration by combining with some of the iron compounds in the clay and forming a white product instead of the characteristic "red" usually produced by the iron. To avoid these defects it is best to add the barium carbonate in a continuous stream and to add it at the earliest possible stage in the treatment of the clay. When properly used no material so effectively prevents soluble salts in a clay from doing harm. R.A.H.

Soluble salts in masonry. H. BRINTZINGER AND W. BRINTZINGER. *Tonind.-Ztg.*, **55** [43], 630–31 (1931).—Reasons are given for the appearance of soluble salts on masonry. Barium oxide has always proved to be a main preventative. W.M.C.

Origin of the color produced on red bodies by zinc vapor. A. MCKINLEY GREAVES-WALKER. *Jour. Amer. Ceram. Soc.*, **14** [8], 578–82 (1931).

Laboratory equipment for stiff-mud tests including exhaustion of the air. ELLIS LOVEJOY AND H. E. COVAN. *Jour. Amer. Ceram. Soc.*, **14** [8], 533–40 (1931).

Application of the downdraft principle to tunnel kilns. W. D. RICHARDSON. *Jour. Amer. Ceram. Soc.*, **14** [8], 572–77 (1931).

Contribution to the study of the mechanical drying of ceramic products made from tender clays. R. DE BLOTTEFIÈRE. *Céramique*, **34** [516], 45–56 (1931).—B. describes in detail the methods by which a particularly difficult brick-clay mixture which for a long time resisted his efforts was finally dried successfully. The study was divided into 3 parts: raw materials, preparation of the mix and products, and drying. The moisture contents, percentage of sand, and drying and firing properties of the three clays entering the mix were determined. A mixture giving a drying shrinkage of 5% was developed and the process adjusted to give a good structure. Full size hollow brick were then dried in an experimental tube drier and the maximum drying rate found to be 1.3 to 2.5% of the total moisture content per hour. In application to practice, the drying process was divided into 2 parts (1) removal of shrinkage water and (2) removal of pore water. The driers used for the removal of shrinkage water were provided with means for recirculating part of the exit air and were nearly self-regulating. These driers are described in detail and diagrams are given. The pore water was removed quickly in another drier using hot, dry air to secure rapid drying. Five "shrinkage" driers were required to feed one "pore" drier. Plans for a complete factory are given. See also *Ceram. Abs.*, 9 [4], 296 (1930). A.E.R.W.

Comments on dry pressing. E. G. CLIFFORD-JONES. *Brick Clay Rec.*, **78** [13], 706–708 (1931).—In discussing articles on dry pressing C.-J. cites examples of personal experience and observation touching on the material discussed in the articles. E.J.V.

Volume changes in brick masonry materials. L. A. PALMER. *Jour. Amer. Ceram. Soc.*, **14** [8], 541–61 (1931).

Reinforced brick masonry. MAJOR L. B. LENT. *Clay-Worker*, **95** [6], 399–402 (1931); see also *Ceram. Abs.*, **10** [8], 569 (1931). E.J.V.

Fundamentals and economies in the clay industries. VI. ELLIS LOVEJOY. *Clay-Worker*, **95** [6], 392–95 (1931).—Some of the data regarding the weights of clays and shales, the tonnage in clay beds, and the value of clays are presented. Several methods

of valuing clay properties are discussed. For Part V see *Ceram. Abs.*, **10** [8], 596 (1931). E.J.V.

Mechanical preparation vs. hand preparation of clay for brick. ANON. *Tonind.-Ztg.*, **55** [50], 724–25 (1931). W.M.C.

Economical considerations in the brick industry. ANON. *Tonind.-Ztg.*, **55** [47], 685–86 (1931).—Different economic problems in connection with the brick industry such as transportation facilities, drying, and firing are discussed briefly. W.M.C.

Heat economy in sand-lime brick plants. W. RAISS. *Tonind.-Ztg.*, **55** [35], 507–508 (1931).—The heat- and power-generating plants of a sand-lime brick plant are described and their efficiency is discussed. After certain changes in the plant were made a large saving of coal was gained per 1000 brick. W.M.C.

Excavating sand for sand-lime brick by means of the "Mammut pump." ANON. *Tonind.-Ztg.*, **55** [50], 725 (1931).—Sand is excavated by introducing high-pressure air into the end of a pipe which is filled with water. The sand is sucked into the pipe line and transported to where it is wanted. W.M.C.

Brick industrial chimneys. ANON. *Brass World*, **27** [6], 138 (1931).—Industrial chimney construction and repair service is offered by the Northwestern Chimney Construction Co. The company specializes in design and building of brick stacks of great height. A specialty is the construction of perforated radial brick chimneys of large dimensions. E.P.R.

Brickote for walls. R. H. GREEN. *Brick Clay Rec.*, **78** [12], 634–37 (1931).—Brickote is a slab of fired clay made in the same way and of the same material as regular face brick. It is only $^1/_2$ in. thick and the slabs are mounted on insulating board and nailed to the wall which is being remodeled. The construction and application of the new product is discussed in detail. Illustrated. E.J.V.

New England special molded brick. HARRY ALBRO' WOODWORTH. *Clay-Worker*, **95** [6], 402–404 (1931).—Wellesley College's new tower represents the first architectural achievement in which the New England Brick Co.'s specially molded Harvard hand-made water-struck brick were used. Fifty thousand brick of 125 designs were used. Illustrated. E.J.V.

Gray brick made from Canadian clay. ROBERT J. MONTGOMERY AND JAMES S. LITTLE. *Brick Clay Rec.*, **78** [13], 686–88 (1931).—A progress report on work being done with several different Canadian clays and five varieties of black glass to produce gray brick is presented with details of chemical composition of the materials used, etc. E.J.V.

Material for light construction. H. BAUSCH. *Giorn. chim. ind. applicata*, **13** [5], 244 (1931).—A new material for light construction has been manufactured by the I. G. Farbenindustrie A.-G. from fused calcium silicate. This material has a foamy appearance when solid, is similar to pumice stone, and is very light as it is 80% pores. It is difficultly permeable to water because the pores are closed. This product, known as "sintoporite," can be used for heat-insulating material, for filling material for cements of best quality, and for the preparation of stone and roofing material. M.V K.

Decorative treatments of brick. ANON. *Brick Clay Rec.*, **78** [13], 696–97 (1931).—Some photographs of particularly effective decorative treatments using brick are presented. E.J.V.

BOOKS

Modern Brickmaking. ALFRED B. SEARLE. Reviewed in *Brit. Clayworker*, **40** [469], 76 (1931); see also *Ceram. Abs.*, **10** [7], 531 (1931). R.A.H.

Brickwork and Its Construction. WALTER R. JAGGARD. *Arch. & Bldg.*, **58** [1], 14 (1931); see also *Ceram. Abs.*, **10** [5], 348 (1931). E.P.R.

PATENTS

Wall construction. DONALD D. WHITACRE AND JOHN C. WOOD. U. S. 1,811,411, June 23, 1931. A composite brick and tile wall comprising face brick laid in a plurality of stretcher courses, tile blocks behind the face brick having integrally formed lips extending into the brick-facing portion of the wall between stretcher courses of brick, and brick units disposed with a lesser lateral dimension than the width of the stretcher brick and comprising part of the wall facing and lying flush with the face of the wall and disposed horizontally adjacent the tile lips between the first-named stretcher courses of brick.

Brick-handling hoist. ROBERT A. FONTAINE. U. S. 1,811,924, June 30, 1931. A brick-stack handling hoist comprising a fork-like structure of substantially L-shape and including horizontal and vertical portions, the horizontal portion being formed as a plurality of arms adapted to engage beneath a stack of brick and the vertical portion having a plate constituting a back against which the stack may rest when lifted, the vertical portion leading to an integral inclined upper portion of substantially the same width, suspension elements at the top of the inclined portion, and other suspension elements at the juncture of the inclined portion with the vertical portion.

Brick sander and method. FLAKE F. STEEL. U. S. 1,812,809, June 30, 1931. A device for sanding a brick clay column comprising a receptacle of substantial depth having opposite walls provided with apertures for the passage therethrough of a formed clay column, the receptacle being of substantially greater width than the column and designed to contain sand covering the column, means in the receptacle above the clay column for flushing water thereon, means in the lower part of the receptacle at each side thereof for preventing the escape of material therein, and spring-pressed wipers arranged to engage the sanded faces of the column to remove excess sand therefrom.

Brick cleaner. WILLIAM R. BANKSON. U. S. 1,813,014, July 7, 1931. In combination, a brick cleaner comprising a pair of spaced, cylindrical, horizontally disposed brushes, a pair of spaced, cylindrical vertically disposed brushes, means for rotating each pair of associated brushes in opposite directions with respect to each other, a conveyer element operable for conveying the brick between each of the pairs of brushes to be acted upon by the latter, a shield member partially enclosing one pair of the brushes, the shield member being formed to provide a pair of passages for the brick, one of the passages communicating with one of the brushes and the other of the passages communicating with the clearance between one pair of the brushes.

Brickmaking machine. ROBERT A. PARRY. U. S. 1,814,227, July 14, 1931. In a brick-forming machine, the combination with a feed chamber having an open bottom, of a mold carrier movable to bring a mold into and out of position to receive clay from the chamber, a plunger operating in the chamber to force clay through the open bottom thereof into the mold, a rock shaft situated beneath the mold carrier, arms on the rock shaft, a connection between one arm and the mold carrier and between another arm and the plunger, and means to oscillate the shaft.

Brickmaking machinery. C. WHITTAKER & CO., LTD., AND N. WHITTAKER. Brit. 349,187, June 4, 1931.

Obtaining a highly-porous cellular light material from blast-furnace slag, etc. C. H. SCHOL. Brit. 350,526, June 24, 1931.

Treatment of brick, concrete, tile, etc. H. E. DOUGHTY. Brit. 350,445, June 24, 1931.

Refractories

Tests on the gas permeability of refractory materials. A. KANZ. Forsch. Inst. Ver. Stahlwerke A. G., Dortmund, 2 (1930); *Ind. Silicati*, **9** [4], 16 (1931).—The gas permeability of chamotte, silica brick, magnesite material, special material, and isolating material was tested. The following formula was used: $\frac{m^3\ cm}{m^2\ h\ mm\ WS}$ where m^3 represents the number of cubic meters of gas penetrating m^2, the surface in square meters through which the gas passes, *cm* the thickness of the material in centimeters, *h* the time expressed in hours, and *mm WS* the difference of pressure in millimeters of a column of water between two opposing walls of the material. The unit of porosity is that which corresponds to the passage of 1 cu. m. of gas through 1 square m. of surface in 1 hr. with the difference of pressure of 1 mm. of a column of water between the two opposing walls of the material and the material itself, 1 cu. m. in thickness. The values agree well with those previously determined by other investigators with the exception of the value for chromite. Up to the difference in pressure of 300 mm. of a column of water, the permeability to the passage of gas is directly proportional to the pressure. There are great variations in the value of the permeability not only for similar materials manufactured from the same raw products and by the same process, but also within a given material itself. The permeability depends on the nature and the number of pores. The method of manufacture and especially the firing temperature greatly influence the porosity and consequently the gas permeability of materials. See also *Ceram. Abs.*, **9** [12], 1055 (1930). M.V.K.

Gas permeability of refractory materials. K. ENDELL. *Arch. Wärmewirt.*, **12** [5], 146 (1931).—The investigations on the gas permeability of refractory materials carried out by A. Kanz (see *Ceram. Abs.*, **9** [12], 1055 (1930)) are reviewed. The values received show large variations for the different types of refractories. The gas permeability seems to be a function of the forming and distribution of pores whereas other properties such as porosity are of no influence. The main factor for the gas permeability lies in the making of the brick, especially in the firing temperature. See preceding abstract. W.M.C.

Chemical analysis of refractory materials. W. KÖNIG. *Tonind.-Ztg.*, **55** [42], 616–18 (1931).—A discussion is given on the paper by van Royen (see *Ceram. Abs.*, **9** [8], 651 (1930)). Different methods of chemical analysis are presented. See also *Ceram. Abs.*, **9** [11], 941 (1930). W.M.C.

Refractories for use in tunnel kiln. M. C. BOOZE. *Fuels & Fur.*, **9** [2], 205–12 (1931).—In kilns used for firing at cone 12, or below, the service on the refractories is not severe and there is little difficulty in obtaining suitable material, except for the fire boxes, car slabs, and car furniture. In kilns fired above cone 12, materials more resistant than first-grade fire brick are usually used in the main arch and side walls. It is essential that the refractories used in tunnel kilns be free from shrinkage and deformation. This requirement can ordinarily be met by hard-fired material. The two methods of determining residual shrinkage in fireclay brick which are most frequently used, are the reheating test and the simulative service test. The hot rigidity of fireclay brick is found by the standard load test. The special refractories used in the firing zone and fire boxes of kilns operating at cone 12 or above include high-alumina brick made of diaspore, silicon carbide, fused alumina, sillimanite and mullite, and kaolin. Kiln-car slabs are usually made of special fireclay mixtures and in some kilns super-refractories such as silicon carbide and sillimanite are necessary to carry the weight of the ware without deformation. For kiln-car furniture, silicon carbide or "semisilicon carbide" is generally used. It is also used most extensively for muffles for tunnel kilns, although fused alumina, mullite, and sillimanite are also used. A.E.R.W.

Refractory materials for electric furnaces. II. Copper and its alloys, including bronze, gun metal, brass, copper-nickel, and phosphor-bronze. ALFRED B. SEARLE. *Metal Ind.* [London], **38**, 333–35 (1931).—The most important types of electric furnaces for melting copper, brass, bronze, etc., are the direct arc, the indirect arc, the induction, and the granular resistance. The direct-arc type furnaces are suitable only for bronzes and alloys containing less than 6% Zn, while the indirect-arc types are applicable to all Cu alloys. The Pb content of the alloy determines the type of lining, magnesite being preferable when Pb is present though Zn may react with a MgO lining. In the Ajax-Wyatt furnace for melting yellow brass, a lining consisting of a refractory cement of a composition corresponding to a mixture of fire clay, SiO_2, and asbestos fiber is often used. Fireclay brick are generally satisfactory. Silica brick are used for the roof and the parts of the sides not coming in contact with slag. Pure magnesia brick, fully fired and enclosed in steel cases, show long life. Zirconia brick are highly refractory but very expensive. The use of fritted linings has increased widely the range of metals for the linings of industrial furnaces of the Ajax-Wyatt type and has increased greatly the number of runs obtainable without relining the furnace. For Part I see *Ceram. Abs.*, **10** [7], 504 (1931). (*C.A.*)

Refractory products for use with pulverized coal firing. F. DUPUIS. *Rev. mat. constr. trav. pub.*, pp. 15–17 (1930); see also *Ceram. Abs.*, **9** [12], 1056 (1930). (*J.I.S.I.*)

Refractory natural rocks for industrial kilns. H. KALPERS. *Chem. Zentr.*, **ii**, 3835 (1930); for abstract see *Ceram. Abs.*, **10** [4], 274 (1931). (*B.C.A.*)

Comparative resistance of refractories to coal-ash slags. R. K. HURSH. *Engineering*, **12**, 794 (1930); *Refrac. Jour.*, **6** [65], 184 (1931).—A clear account is given of the processes by which the slagging of refractories by coal ash in boiler furnaces takes place and of the parts played by the various factors. The tests applied in the investigation consist in measuring on test brick, arranged as the lining of a rotary furnace, the combined effect of corrosion and erosion produced by the slag under investigation when fed into the furnace as a powder at a uniform rate under controlled temperature and atmospheric conditions. A number of different brick were tested with different slags and at various temperatures. Observations were also made for a variety of slags, for the effect of variations in method of manufacture, fineness of grind, temperature of prime after manufacture and before use, and materials. See also *Ceram. Abs.*, **9** [8], 651 (1930). A.A.

Effect on refractories of the desulphurizing and refining of gray cast iron with soda ash. E. W. COLBECK AND N. L. EVANS. *Refrac. Jour.*, **7** [6], 324 (1931).—There is no doubt that prolonged exposure of siliceous refractories to slags containing sodium compounds results in serious attack. In foundries, when ladles up to 2 tons are used, it is usual to line the ladle with a ganister daub which is knocked out at the end of the day's run. Under these circumstances the question of lining attack does not arise. Where large brick-lined ladles are employed, however, the best results are obtained by using Scotch fireclay brick having a close even texture and good resistance to spalling. E.P.R.

Study of refractory materials. II. COLIN PRESSWOOD. *Blast Fur. Steel Plant*, **19** [7], 1016–18 (1931).—Thermal and electrical conductivity of refractories is discussed and data on these properties of different types of refractory materials are presented. The causes of spalling are briefly touched upon. For Part I see *Ceram. Abs.*, **10** [8], 573 (1931). E.J.V.

Simple method for studying the rate of quartz inversions in refractories. W. A. SEGER AND E. CRAMER. *Tonind.-Ztg.*, **55** [49], 712–13 (1931).—For studying the rate of quartz inversions in refractories, powder samples should be taken from different

parts of the brick and examined under the microscope. In this way it is easy to determine the amount of quartz not inversed. W.M.C.

Separation of cyanite and mica from materials of mica schist. ANON. *Brick Clay Rec.*, **78** [13], 698–99 (1931).—After a discussion of the properties of the associated minerals, methods of separating mica and cyanite are described. It is shown that by crushing, screening, tabling, and then possibly employing additional screening and water classification, high purity concentrates of mica and cyanite may be obtained. Factors influencing the concentration efficiency are enumerated. E.J.V.

Grain sizes for dense refractories. K. LITZOW. *Tonind.-Ztg.*, **55** [49], 709–10 (1931).—Within the last four years several papers have been published on grain sizes for dense refractories. L. reviews the results and concludes that for plant work, graphs should be drawn showing the best distribution of grain sizes in a certain body to give the best results of the finished product. See also *Ceram. Abs.*, **10** [5], 354 (1931). W.M.C.

Magnesia in refractory brick. H. ECKSTEIN. *Refrac. Jour.*, **7** [6], 328 (1931); for abstract see *Ceram. Abs.*, **10** [8], 602 (1931). E.P.R.

Making magnesite brick. ANON. *Brick Clay Rec.*, **78** [13], 698 (1931).—A brief nontechnical discussion of the materials and methods involved in the manufacture of magnesite brick in the U.S. is presented. Some of the processes in use in making unfired brick to save the expense of firing them are discussed briefly. E.J.V.

Performance of slip cast tank blocks; studies of clay mixtures for glass pots. ANON. *Ceram. Ind.*, **17** [1], 18–19 (1931).—P. Haller discusses the manufacture and performance of slip cast tank blocks. J. H. Partridge discusses clay mixtures for glass pots. Studies made on this subject by the General Electric Co., Ltd., are described and causes of failure of glass pots are included. The effect of various mixtures on resistance to thermal shock is given. See following abstract. W.W.M.

Clay mixtures for glassmelting pots. J. H. PARTRIDGE AND G. F. ADAMS. *Refrac. Jour.*, **7** [6], 328 (1931); for abstract see *Ceram. Abs.*, **10** [8], 573 (1931). E.P.R.

Refractory protective coatings. L. LITINSKY. *Feuerfest*, **7** [5], 65–80 (1931).—A survey of the best-known protective coatings, their properties, composition, and the proper field for their use, and a description of apparatus for applying coatings on kiln walls are given. A list of publications on refractory mortars, linings, coatings, and plastic pastes follows. M.V.K.

High heat-duty refractories. F. W. SCHROEDER. *Refrac. Jour.*, **7** [6], 328 (1931); for abstract see *Ceram. Abs.*, **10** [7], 504 (1931). E.P.R.

High-fired kaolin refractories. F. H. NORTON. *Trans. A.S.M.E.*, **53** [8], 173–75 (1931).—The development of high-fired kaolin refractories is briefly described. E.P.R.

Some of the newer uses for silicon carbide. C. MCMULLEN. *Trans. Amer. Electrochem. Soc.*, **59**, 199–204 (1931); for abstract see *Ceram. Abs.*, **10** [8], 578 (1931). (*B.C.A*)

Effect of titanium in refractory materials. H. HIRSCH. *Refrac. Jour.*, **7** [6], 328 (1931); *Chem. Zentr.*, **ii**, 1115–16 (1930); for abstract see *Ceram. Abs.*, **9** [10], 851 (1930). E.P.R.

Determination of alumina in refractory clays. R. BIAZZO. *Refrac. Jour.*, **7** [6], 328 (1931); for abstract see *Ceram. Abs.*, **10** [8], 602 (1931). E.P.R.

Schlenkermann's stone. KALPERS. *Giess*, pp. 1045–47 (1930); *Refrac. Jour.*, **7** [6], 328 (1931).—Schlenkermann's stone consists of 90% silica and 7% alumina with small quantities of the oxides of iron, soda, and potash. Details are given of the various industrial applications of the stone. E.P.R.

Argentine market for refractory materials. CHARLES H. DUCOTE. *Commerce Repts.*,

No. 11, pp. 713–14 (1931).—Argentine import trade in refractory materials has not varied greatly in recent years, totaling 6,237,000 in 1926, 6,272,000 in 1927, 10,003,000 in 1928, and 6,192,000 in 1929. The other principal item imported is refractory earth. About 75% of the imported brick are of British manufacture, the remainder being from American and Belgian firms. Low grades are usually purchased. The trade with the U.S. is largely in brick and shapes. Local production of refractory brick is important. Imports of refractory earth are fairly stationary. Distribution methods are discussed. E.J.V.

Refractory industry and its importance for Germany. ANON. *Tonind.-Ztg.*, **55** [49], 710–12 (1931). W.M.C.

BOOK AND BULLETIN

Laboratories for Testing Refractory Materials. (Prüfanstalt für feuerfeste Materialien.) L. LITINSKY. Reviewed in *Rev. mat. constr. trav. pub.*, No. 255, p. 240*B* (1930); see also *Ceram. Abs.*, **10** [2], 126 (1931). A.J.M.

Babcock & Wilcox Co. presents new bulletins. ANON. *Amer. Glass Rev.*, **50** [39], 14 (1931).—"B. & W. No. 80 Insulating Firebrick" discusses a new insulating fire brick for furnace work. The insulating and refractory characteristics are illustrated by curves, sketches, and calculations. Examples of advantages are given. E.P.R.

PATENTS

Heat-conducting high temperature resistant refractory. JOHN D. MORGAN, WILLIAM G. BJORKSTEDT, AND RUSSELL E. LOWE. U. S. 1,811,242, June 23, 1931. A composition of matter comprising substantially equal parts of zircon and silicon bonded by reaction products of phosphoric acid therewith and having a coefficient of heat transmission equal to bonded silicon carbide at temperatures above 2000°F and capable of commercial use at 2600°F.

Refractory material. TURE ROBERT HAGLUND. U. S. 1,811,314, June 23, 1931. As a new article of manufacture, a fused refractory material containing not less than 15% of oxide of magnesium, not less than 5% of oxide of chromium, not less than 75% of oxides of magnesium, aluminum, and chromium counted together, and with a content of silica less than 12% and of oxide of iron less than 5%, characterized by high softening temperature and resistance against chemical erosion.

Furnace wall. HOWARD C. THAYER. U. S. 1,811,373, June 23, 1931. In a furnace wall, the combination of a series of tubes, clamps secured to the tubes and constructed to hold the tubes spaced from each other and in a definite positional relationship to each other, refractory blocks protecting the tubes and clamps, and additional means for securing the blocks to the tubes.

Making high temperature heat-insulation material. CARLTON EARLE MILLER. U. S. 1,811,516, June 23, 1931. A heat-insulating material comprising a mixture of diatomaceous earth, calcium carbonate, and basic magnesium carbonate.

Insulating material. ARTHUR J. RUSS. U. S. 1,812,306, June 30, 1931. An insulating material comprising a mixture of an alkaline earth, diatomaceous earth, and an exfoliated vermiculite mineral.

Air-cooled furnace wall. HENRY H. BAUMGARTNER. U. S. 1,812,315, June 30, 1931. An air-cooled furnace wall comprising a facing built up of refractory elements and a backing spaced therefrom to leave interior air spaces outward of the rear surfaces of the face elements, the wall having air inlets and outlets arranged for air flow through the spaces for scrubbing or cooling of the face elements, and interior means tying the facing to the backing at intervals while allowing movements of the face elements in the plane of the walls, the face elements in each wall section being separated horizontally,

lap jointed and packed, and interlocked vertically with packing at the top of the wall section, and cover tile above.

Refractory heat-insulating material. DONALD W. ROSS AND JAMES M. LAMBIE. U. S. 1,812,376, June 30, 1931. A heat-insulating body which includes a bonding material and grains of cyanite of such gradation of sizes as to result in minimum density of piling.

Furnace lining. HENRY WILLIAM WILDISH. U. S. 1,813,790, July 7, 1931. In a furnace, a furnace casing, a substantially rectangular lining brick formed with an undercut cavity communicating with the face of the brick, adjacent the casing by a passage of reduced cross-section, but internally closed to the remaining faces of the brick, and a bolt passing through the casing and the passage and anchored within the cavity to clamp the brick to the casing whereby the bolt is insulated from the heat of the furnace.

Making refractory material. GEORGE SCOTT HOUSMAN. U. S. 1,814,088, July 14, 1931. Method of producing a refractory body which comprises mixing together finely divided silica and chromite, forming the mixture or portions thereof into the shape desired, and thereafter subjecting the same to high temperature.

Aluminous abrasive. NORTON CO. Brit. 350,561, June 24, 1931.

Refractory mortars. E. LUX. Brit. 351,067, July 1, 1931.

Building door arches and roofs for furnaces, etc. J. SHACKLETON. Brit. 351,578, July 8, 1931.

Furnace walls. BABCOCK & WILCOX, LTD. Brit. 351,822, July 8, 1931; see also *Ceram. Abs.*, **10** [4], 278 (1931).

Terra Cotta

Pressing, drying, and glazing terra cotta. H. SPURRIER. *Fuels & Fur.*, **9** [1], 101–103 (1931).—In the pressing of terra cotta, the mold must exceed (in all dimensions) the finished size by an amount equal to the sum of the drying and firing shrinkage. Great differences in shrinkage may be occasioned by the manner in which the body is pressed into the mold. Pressing should always be done as expeditiously as possible and the pressed ware taken out of the mold as soon as it has "set up" sufficiently. The surfaces that require it are then "finished." After this the body is dried, usually in humidity driers. The relative humidity is kept at 60 to 70% until the mass is brought up in temperature and the humidity is gradually reduced. The reduction of the humidity must not be too rapid. Circulation of the atmosphere in the drier should be thorough and uniform in order to prevent differential shrinkage and consequent warping. Care in placing the ware in the drier will also help to prevent warping. Raw and fritted glazes are used on terra cotta. The glazing is done by spraying. Duplications of color, mottle, and surface texture may be secured in this step. A.E.R.W.

Stock terra cotta. M. BARRETT. *Brit. Clayworker*, **40** [469], 78–79 (1931).—There are buildings on which faience could be used if it were readily procurable at a low price. The principal mitigating reasons are (1) high cost, (2) long time delivery, and (3) publicity. B. discusses the advantage of standardizing shapes and other means of overcoming some of the features limiting its use. R.A.H.

Use of lepidolite in zincless glazes. H. E. DAVIS AND R. L. LUEDERS. *Jour. Amer. Ceram. Soc.*, **14** [8], 562–64 (1931).

Silicates in the chemical industry in special consideration of the resistance against chemical agents. V. SKOLA. *Ber. deut. keram. Ges.*, **12** [3], 122 (1931); for abstract see *Ceram. Abs.*, **9** [5], 387 (1930). I.R.

Some effects of thermal shock in causing crazing of glazed ceramic ware. H. G. SCHURECHT AND D. H. FULLER. *Jour. Amer. Ceram. Soc.*, **14** [8], 565–71 (1931).

Glazed brick. ANON. *Brick Clay Rec.*, **78** [12], 638–46 (1931).—The various methods used in producing different colors of brick are briefly discussed. As these methods do not permit certainty of reproduction of all colors accurately at all times, glazing of the brick has come into vogue. The methods and processes used in the production of glazed brick are taken up in considerable detail, starting with definitions of glazes and engobes, discussing the functions of the various ingredients, colors produced by the different oxides, grinding time, speed of the mill, application, kiln setting, etc. Illustrated. E.J.V.

Interior walls of glazed brick. ANON. *Brick Clay Rec.*, **78** [12], 650–55 (1931).—Numerous photographs illustrating novel applications of glazed brick for interior walls in a number of different types of buildings ranging from private homes to large public buildings are presented. E.J.V.

Glazed masonry. ANON. *Brick Clay Rec.*, **78** [12], 649 (1931).—Illustrations of some of the outstanding buildings in this country which are being built with exterior walls of glazed brick are presented. E.J.V.

Weatherproof overglaze colors. O. HOMMEL CO. *Brick Clay Rec.*, **78** [12], 664 (1931).—A series of weatherproof overglaze colors which can be sprayed on white glazed brick and fired at cone 017 to 015 for $1^1/_2$ to 2 hr. has been developed. This method is lower in production cost and offers a decided advantage in shop practice. E.J.V.

Colored brick, etc. JOHN L. WALSH AND S. STEVENSON. *Brick Clay Rec.*, **78** [12], 656–62 (1931).—Seven general ways by which brick and clay products have been decoratively colored are (1) surface coloration of the brick during firing in the kiln by a method known as flashing or by the introduction into the kiln atmosphere of volatile salts, (2) coloration of the entire brick, (3) spraying of soluble coloring salts upon the surface of the brick or clay product, (4) application of vitreous colored particles during a molding process, (5) application of vitreous colored particles by a method similar to sandblasting, (6) surface coloration by means of a thin water coating, and (7) application of a colored glaze. Each is discussed in detail. Color as a great sales force and possible markets for colored clay products are discussed. Illustrated. E.J.V.

Interior walls of clay. III. ANON. *Brick Clay Rec.*, **78** [10], 544–45 (1931).—Examples of the use of clay products in interior walls in a church, a grocery store and meat market, and a large German bakery are illustrated. **IV.** *Ibid.*, **78** [11], 583–86 (1931).—This article discusses the use of clay products for inside walls and fixtures in such places as meat markets, grocery stores, bake shops, etc. Comparisons of costs of various types of walls are made. Illustrated. For Parts I and II see *Ceram. Abs.*, **10** [7], 502 (1931). E.J.V.

500 Fifth Avenue Bldg. ANON. *Arch. & Bldg.*, **58** [3], 73 (1931).—The exterior is of buff brick with dark gray terra cotta for spandrels with limestone trim. E.P.R.

National Hotel of Cuba. ANON. *Arch & Bldg.*, **58** [3], 60 (1931).—The towers are surmounted by glazed, polychrome tile pinnacles in brilliant colors and are roofed with Spanish tile. The wings and main building are surmounted by a pierced stone balustrade. As a modern adaptation of Spanish architecture, the finish is in pink stucco trimmed with a native, light buff jaimanitas limestone. E.P.R.

PATENT

Building construction. ALBERT F. BEMIS. U. S. 1,810,891, June 23, 1931. A wall construction comprising a row of parallel studs, a layer of slabs upon each side of the row, the slabs having intermediate grooves in interfitting engagement with certain of the studs, and having marginal portions cut away to engage studs at their edges.

White Wares

Graphical representation of the molecular formulas of ceramic glazes. H. H. HOLSCHER AND ARTHUR S. WATTS. *Jour. Amer. Ceram. Soc.*, **14** [8], 583–87 (1931).

Influence of magnesite on earthenware clays. OTTO KRAUSE AND EBERHARD KEETMAN. *Ber. deut. keram. Ges.*, **12** [3], 99 (1931).—The influence of magnesite, $MgCO_3$, or magnesium oxide on the clay substance of different typical earthenware clays has been examined to compare with the effect of analogous Ca combinations and also to test whether the use of Mg carbonate or oxide might not be more useful in sanitary earthenware than lime. The experiments have been conducted in the same way as those for the lime addition to clays (see *Ceram. Abs.*, **10** [5], 393 (1931)). The data contain results of X-ray tests, determinations of specific weight, porosity, volume weight, and resistance against load. Some technically important results are given. A mixture with 10% magnesite has a higher load resistance, lower porosity, and a longer sintering interval (2 cones difference) than mixtures with less magnesite. Compared with lime mixtures all magnesite mixtures have a longer sintering interval which is important in the firing of technical earthenware. For this reason it is important that all magnesite mixtures be 100% higher in strength than the corresponding lime mixtures. The difficulty that might prevent the use of magnesite in earthenware might be the glazing. I.R.

Steatite and similar bodies. L. RANCKE. *Sprechsaal*, **64** [23], 427–29 (1931).—Many plants producing chinaware are using steatite, etc. The main advantages of the new bodies are (1) a high resistance against compression, (2) tension and mounting, (3) high density, (4) exact dimensions of the products, (5) good insulating qualities, and (6) only small changes of color. It is possible to apply certain white and black glazes to steatite bodies. R. points out that similar bodies may be obtained by a combination of stoneware and porcelain bodies. A comparison is given between porcelain bodies with and without different amounts of additional constituents. W.M.C.

Investigation of feldspar and its effect in pottery bodies. R. F. GELLER AND A. S. CREAMER. *Ber. deut. keram. Ges.*, **12** [6], 293–96 (1931); for abstract see *Ceram. Abs.*, **10** [2], 128 (1931). E.J.V.

Silicon carbide as a contamination of chinaware bodies and glazes. S. BERG. *Sprechsaal*, **64** [25], 468 (1931).—Silicon carbide added to chinaware bodies gives rise to several defects in the chinaware produced. This is the reason the use of this material should be avoided entirely. W.M.C.

Researches on the use of an artificial substance, Taumalit, for tableware. F. FISCHLER AND J. SCHWAIBOLD. *Keramos*, **10** [10–11], 265–68 (1931).—Taumalit (Isopressstoff) is an opaque, artificial substance which can be colored in different shades; the surface is polished. It has good resistance to strokes, its density is 1.47 (density of porcelain is 2.46), and is stable to heat to about 150° (porcelain, 1200°). Cups and plates of this material were examined. Taumalit is resistant to acids but less resistant to alkalis. It can be used in some cases for tableware. M.V.K.

Bureau of Standards' study of gases evolved by feldspar. ANON. *Amer. Glass Rev.*, **50** [35], 12 (1931).—The Columbus Branch of the U. S. Bureau of Standards is conducting a study of gases evolved by feldspar during heating. E.P.R.

Development of Canterbury vellum. ANON. *Ceram. Ind.*, **17** [1], 17 (1931).—Canterbury vellum, made by Homer Laughlin China Co., was developed as a colored background to suit modern decorative schemes. A rich effect is obtained by making the glaze nonreflecting. W.W.M.

Manufacture of A C-Sphinx Sparking Plugs. ANON. *Engineering*, **131** [3407], 572–73 (1931).—The works of A C-Sphinx Sparking Plug Co., Ltd., Birmingham, England, is described and illustrated. A.A.

Making a hard porcelain group. ANON. *Pottery Gaz.*, **56** [649], 986–87 (1931).—A description of the various processes employed in the making of a hard porcelain group at the Selb works of Rosenthal & Co., Meissen, Germany, is given and is illustrated with eleven photographs. E.J.V.

German porcelain industry. ANON. *Times Eng. Supp.*, **28,** 78 (1931).—The Government Commission on German industries has published its report on the porcelain industry. There are 290 plants employing 69,000 persons, producing 135,000 T. per annum, of value, 200 million marks. Compared with 1913, production of household porcelain has increased 15 to 25%, ornamental porcelain has fallen 50%, and technical porcelain has at least doubled. The British safeguarding duty has impeded the export of household porcelain, but in technical porcelain, Germany leads the world with 35% of the total exports. H.H.S.

Limoges porcelain. ANON. *Céram. Verrerie*, **49,** 455 (1929).—A brief historical review is given. A.J.M.

Ceramic Society in Germany. II. ANON. *Pottery Gaz.*, **56** [649], 974–81 (1931).—A description of the State Porcelain Manufactory at Meissen and a clay mine at Lothain, on the outskirts of Meissen, visited during the tour is presented. Illustrated. For Part I see *Ceram. Abs.*, **10** [8], 612 (1931). E.J.V.

BOOK

Electrical Insulating Materials. H. WARREN. Ernest Benn, Ltd., London. *Electrical Rev.*, **108** [2790], 854 (1931).—The volume is divided into seven sections and deals particularly with materials and manufacturing processes, covering the engineering aspects of all the important types of insulators used in the construction of an electrical plant. E.P.R.

PATENTS

Insulating device. FRANK G. BAUM. U. S. 1,811,530, June 23, 1931. An insulator comprising an elongated tubular porcelain body, a metal cap secured upon one end of the body, a bolt extending axially within the body, a mass of cement embedding one end of the bolt within the end of the body, the other end of the bolt projecting beyond the other end of the body, and a mass of water-repellent plastic material filling the space within the body between the mass of cement and the second-named end and acting to center the bolt.

Ware support. ROGER W. ROWLAND. U. S. 1,813,085, July 7, 1931. A support for ceramic ware comprising an elongated main supporting member having a base flange and a vertical web, and a plurality of horizontally extending ware-supporting members extending laterally from the web.

Insulator. HOBART M. KRANER. U. S. 1,813,172, July 7, 1931. A tension insulator comprising oppositely spaced terminal structures, a plurality of insulating elements connected therebetween to subdivide the tension load, and yieldable means between the insulating material of each element and the next adjacent part of one of the terminal structures to balance the load divisions relative to each other.

Edge decoration. CHARLES O. SMITH. U. S. 1,813,551, July 7, 1931. The underglaze process of edge-decorating table earthenware which consists in applying a ripple or featheredge water-color decoration to the edge portion of a piece of unglazed earthenware, dipping the decorated earthenware before firing to glaze the same, and then firing the glazed earthenware.

Attachments for preventing dripping from spouts of teapots, etc. C. H. TURNER. Brit. 351,286, July 1, 1931.

Equipment and Apparatus

Photoelectric cells. F. SCHROETER. *Z. tech. physik*, **12** [4], 193–200 (1931).—This paper gives an interesting review on photoelectric cells, especially of those developed in the last few years. Photocells for infra-red investigations, photocells with monoatomic layers, gas-filled cells, combinations of photocells and amplifiers, etc., are described. Many photos and curves are given showing the way the different cells are used.
W.M.C.

Photoelectric tubes in recording instruments. ANON. *Pit & Quarry*, **22** [4], 79 (1931).—A beam of light has no weight, so by incorporating photoelectric and pliotron tubes in recording instruments, it has been made possible to record quantities where only a limited amount of energy is available. E.P.R.

Solving drying characteristics of clay. H. SPURRIER. *Brick Clay Rec.*, **78** [13], 691–94 (1931).—An apparatus used for determining loss of weight and shrinkage of clay bars on drying is described. Data on Illinois and Ohio clays, mixtures of the two, and batches mixed with salt solution additions to the tempering water and also with ammonia in the tempering water are plotted graphically and discussed. Illustrated.
E.J.V.

Determination of calorific value of gases. ANON. *Gas Age-Rec.*, **67** [24], 932 (1931); reprinted from *Arch. Warmewirt.*, **11**, 12 (1930).—The Strache-Loeffler calorioscope consists of a combustion chamber formed by a double-walled sphere which is designed on the thermos-bottle principle. Illustrated. E.J.V.

Improved laboratory furnace. ANON. *Ceram. Ind.*, **17** [1], 59–60 (1931).—An improved gas-fired laboratory furnace for melting small samples of ceramic materials or nonferrous metals has been developed by Babcock & Wilcox Co. Temperatures of 1000 to 2500°F can be reached in 15 to 30 min. and accurately controlled. Illustrated.
W.W.M.

Laboratory furnaces for high-temperature work. N. R. DAVIS AND C. SYKES. *Chem. & Ind.*, **50** [25], 506–14 (1931).—Induction furnaces are described and illustrated with photographs and diagrams. See also *Ceram. Abs.*, **10** [6], 454 (1931). G.R.S.

Reading temperatures with greater accuracy. A. J. MONACK. *Chem. Met. Eng.*, **38** [6], 356 (1931).—Necessity of maintaining the external junction of the thermocouple at a uniform temperature, preferably at 0°C, is emphasized. A well-insulated box provided with a heater and thermostatic control was successfully used to house external junctions of seven couples. G.R.S.

New "p_H" thermometer to save industry millions. DUNCAN A. MACINNESS. *Amer. Glass Rev.*, **50** [38], 12 (1931).—A "p_H" thermometer, the size of a pencil, works on the principle of an electrode and was made suitable for industrial use by employing glass of comparatively low resistance. It reacts only to hydrogen-ion activity.
E.P.R.

Surface pyrometers. ANON. *Instrument World*, **3**, 255–56 (1931).—A novel thermocouple, devised by the Cambridge Instrument Co., consists of a thin wide strip of metal which when applied to a hot surface conforms to the shape of the surface and takes up its temperature almost instantaneously. H.H.S.

Comparison between ordinary thermocouple and suction pyrometers for the measurement of temperature of flowing gases in glass furnaces. M. PARKIN AND F. WINKS. Presented at meeting of Soc. Glass Tech., June 17, 1931. An ordinary thermocouple placed in any current of gas does not indicate the true temperature of the gas whenever there is a substantial difference in temperature between the gas and the confining walls, or any solids in the path of the gas. Screening the thermocouple has not proved satisfactory as a means of eliminating the fault, and the use, suggested by Kreisinger and Barkley, of a thin wire is not practicable on account of the fragility of the instrument.

A more satisfactory method is to employ a form of pyrometer in which the couple is sheathed, the gas being drawn past the junction at a high velocity. Another form of instrument is described, consisting of an electrically heated wire loop to the center of which is attached a thermocouple junction shielded by a tube on the outside and fitted with an inner tube through which the gas is drawn rapidly. By a method of trial and error, the current through the loop is controlled so that the temperature reading is not altered at all when the gas is sucked past the junction.

Improved Feussner type potentiometer. M. EPPLEY AND W. R. GRAY. *Rev. Sci. Instruments*, **2** [4], 242–49 (1931).—A new type of potentiometer is described for accurate work. This instrument is immersed in an oil bath with an electric stirrer and thermostatic control. W.M.C.

New Brown potentiometer pyrometer. THOMAS R. HARRISON. *Brick Clay Rec.*, **78** [12], 664 (1931); *Pit & Quarry*, **22** [4], 78–79; [7], 86 (1931); for abstract see *Ceram. Abs.*, **10** [8], 585 (1931). E.J.V.

Radiation measuring instrument (thermoelement) of increased sensitivity and rapid adjustment. CARL MULLER. *Naturwissenschaften*, **19** [20], 416–19 (1931).—A new radiation thermoelement is described which is more sensitive, handier, and more rapid in adjustment than any which has been described previously. L.T.B.

Pebble mill linings. ROBERT TWELLS. *Ber. deut. keram. Ges.*, **12** [6], 290–92 (1931); see also *Ceram. Abs.*, **9** [10], 857 (1930). E.J.V.

Chart for determining volume porosity. ANON. *Ceram. Ind.*, **17** [1], 23 (1931).—A chart has been developed for determining volume porosity at a glance. W.W.M.

Crushing and grinding materials in the ceramic industry. ANON. *Tonind.-Ztg.*, **55** [50], 725–28 (1931).—Some machines are described for crushing and grinding materials used in the ceramic industry. W.M.C.

Magnetic separators for the clay industries. ANON. *Brit. Clayworker*, **40** [469], 61–64 (1931).—Machines for cleaning iron out of clay are provided with magnets excited by d.-c. electricity in moderate amount. The cost of operation has been much reduced and its practicability proven. R.A.H.

New classifier designed for use at high speeds. ANON. *Pit & Quarry*, **22** [6], 73 (1931).—An entirely new and advanced type of head motion has extended the field of application of Dorr classifiers and permitted the use of higher speeds with a corresponding increase in sand raking and overflow capacities where these high rake speeds are consistent with the separation desired. E.P.R.

Lubricate air lines automatically. ANON. *Abrasive Ind.*, **12** [7], 29 (1931).—C. A. Norgren Co., Denver, has produced a sight-feed automatic air-line lubricator for use on lines serving pneumatic tools of various kinds. Three sizes and types of this device are shown. E.P.R.

Recording color analyzer. ANON. *Chem. Met. Eng.*, **38** [3], 164–65 (1931); see also *Ceram. Abs.*, **10** [5], 372 (1931). G.R.S.

Belt conveyer increases clay storage capacity and workability. GEORGE A. PAIGE. *Brick Clay Rec.*, **78** [13], 704–706 (1931).—A description of the installation and operation of a belt conveyer in the plant of F. W. Ritter Sons, South Rockwood, Mich., is presented. Illustrated. E.J.V.

Determining the trajectory of material discharged by a belt conveyer. ANON. *Pit & Quarry*, **22** [4], 47 (1931).—In locating the chute to receive the discharge from a belt conveyer, it is often desirable to take into account the trajectory or parabolic path the material will take under the combined influences of gravity, the speed of the belt in feet per minute, and the diameter of the head pulley in inches. The somewhat complicated formulas involved have been worked out. E.P.R.

Spraying equipment. III. S. M. STOLER. *Amer. Enameler*, **4** [4], 14 (1931).—

The spray gun and spray booths are described and illustrated. For Parts I and II see *Ceram. Abs.*, **10** [8], 549 (1931). J.D.R.

Test sieves with round holes. ANON. *Tonind.-Ztg.*, **55** [35], 511 (1931).—The German proposed standard specifications for sieves with round holes are given. Twenty-three different sieves with holes from 1 to 100 mm. diameter are included. W.M.C.

"Wedging" trouble from clay batches. A. H. FESSLER AND L. SMALE. *Ceram. Ind.*, **17** [1], 24–26 (1931).—The authors describe with illustrations the wedging table or French Kneading Machine, as used by the A C Spark Plug Co. The method of operation is also detailed. It is recommended for bodies which are "short" and gives a homogeneous mixture free from air bubbles and laminations. The filter cakes are wedged before aging, preparatory to use. W.W.M.

Louthan racks save space. ANON. *Ceram. Ind.*, **17** [1], 60 (1931).—The Louthan Manufacturing Co., East Liverpool, Ohio, has developed racks in which to place dinnerware for firing. The racks are described and illustrated. W.W.M.

Study of cooler, drier, and kiln drives. EDGAR CARLSSON. *Rev. mat. constr. trav. pub.*, No. 255, pp. 495–99 (1930); No. 256, pp. 29–33 (1931); *Pit & Quarry*, **22** [5], 72 (1931).—C. makes a detailed review of the various means of driving rotary kilns, coolers, and driers used in the cement industry, all of which are cylindrical in shape and are rotated slowly on their axes, the slow rotation presenting a special and difficult problem of drive. His conclusions are all for the superiority of the motor and positive-speed reduction gearing, the advantages of which he sums up. See also *Ceram. Abs.*, **10** [7], 481 (1931). E.P.R.

Studies of machines for extruding clay columns. P. C. GRUNWELL. *Tonind.-Ztg.*, **55** [43], 625–28; [46], 670–72; [48], 697–99 (1931); see also *Ceram. Abs.*, **9** [8], 661 (1930). W.M.C.

Apparatus for brick, etc. P. RENAULT. *Rev. mat. constr. trav. pub.*, No. 254, pp. 208–10*B*; No. 255, pp. 235–38*B* (1930); No. 256, pp. 13–17*B*; No. 257, pp. 29–32*B* (1931); see also *Ceram. Abs.*, **10** [8], 588 (1931). A.J.M.

Reasons for replacing equipment before it is worn out. ANON. *Rock Prod.*, **34** [12], 44 (1931); for abstract see *Ceram. Abs.*, **10** [7], 528 (1931). W.W.M.

Ceramic engineering in Germany. ANON. *Pottery Gaz.*, **56** [649], 972–73 (1931).—During the course of the Ceramic Society tour in Germany the devices seen were (1) an automatic friction tile press fitted with fully automatic feeding and discharging devices, (2) an automatic tile-measuring machine, (3) an automatic press of the crank type available for the manufacture of simple small articles, (4) a semi-automatic crank press for electrical porcelain, (5) a sagger-making machine, (6) a twin cup-making machine, and (7) a fully automatic plate machine. Descriptions of these devices are given. See also *Ceram. Abs.*, **10** [8], 612 (1931). E.J.V.

BOOK, CATALOGUE, AND PAMPHLET

Photoelectric Cells and Their Applications. ANON. Physical and Optical Societies, London, 1930. 236 pp. *Mech. World*, **89** [2313], 422 (1931).—In this volume are assembled, in a form convenient for reference, the papers contributed to the discussion on photoelectric cells and their applications at a joint meeting of the Physical and Optical Societies held on June 4 and 5, 1930. E.P.R.

Issue V-belt data. ANON. *Abrasive Ind.*, **12** [7], 36 (1931).—An 84-page V-belt catalogue issued by the L. H. Gilmer Co., gives (1) theoretical and practical illustrations of V-belts and their operation in multiple drives for various classes of service, (2) new, simple, and original formulas for all V-belt calculations, (3) detailed tables of drives from fractional to several hundred horsepower, (4) a large chart for quickly determining center distances, (5) belt lengths, and (6) other useful data. E.P.R.

Engelhard pamphlet on insulating tubes. CHARLES ENGELHARD, INC. *Amer. Glass Rev.*, **50** [25], 15 (1931).—The pamphlet contains two illustrated tables on capillary and insulating tubes whose bores vary from 0.2 to 5 mm. Between these two sizes almost any combination of outside and inside diameters can be obtained. E.P.R.

PATENTS

Brick-stack carrier. ROBERT A. FONTAINE. U. S. 1,811,429, June 23, 1931. A brick carrier comprising a back member equipped with suspension means, a plurality of arm members carried by the back member and adapted to engage beneath a stack of brick, and link and lever means coöperating with the back member for normally maintaining the arm members rigid with respect to the back member, the means being releasable.

Agitator for stokers. JOSEPH H. WALTER. U. S. 1,812,911, July 7, 1931. In a fuel-feeding mechanism the combination of an elongated trough-shaped hopper, a feed worm mounted in the bottom thereof, and a toothed wheel whose tooth length approximates the worm diameter, the wheel having its axis mounted transversely across the hopper above the feed worm.

Touch-up spray gun. SVEND BRAMSEN AND WILLIAM HERSLEB. U. S. 1,812,922, July 7, 1931. In a spraying appliance, a body member, a liquid-controlling needle valve, and an air-valve stem both slidably supported by the body member and both extending forwardly of the body member, an actuating lever straddling the body member and presenting two arms at opposite sides of the body member and of the needle valve, means for pivoting the similar ends of both lever arms to the body member on a common axis, a radial enlargement fast on the needle valve, a second detachable pivoting means extending through the two lever arms, a thrust member pivoted on the second pivoting means and disposed in front of both the air-valve stem and the enlargement, a stop fast on one lever arm and disposed in front of the thrust member at a distance from the axis of the second pivoting means, and spring means continually pressing the air-valve stem forward against the thrust member to hold the thrust member against the stop.

Molding brick. GEORGE SCOTT HOUSMAN. U. S. 1,814,159, July 14, 1931. In apparatus for molding brick, the combination with a plurality of molds, of a power-driven hammer for tamping moldable material in the molds, the hammer having a tamping head pivotally connected thereto, means for supporting the hammer, the means and the hammer being adapted to be positioned in operative relation to any one of the molds, and elastic yielding means having connection with the head at points on opposite sides of the axis of its pivotal movement, the elastic yielding means exerting an upward pull upon the head.

Brickmaking machine. EDWARD D. MARTINET. U. S. 1,814,172, July 14, 1931. A machine comprising a carrier, means for discharging dry material upon the carrier and leveling the material at successively varying heights from the bottom of the carrier; means for moving the carrier in respect to the discharge means, thereby spreading the material in successively superimposed layers, and means applying liquid to the successive layers in spray form to produce a plastic mass.

Molding apparatus. JOHN T. STONEY. U. S. 1,814,416, July 14, 1931. Molding apparatus comprising a table, a movable presser member mounted above the table, means for raising and lowering the presser member, and vibrating mechanism centrally arranged with respect to the presser member whereby the vibrating mechanism imparts blows to the presser member.

Shield for piling brick. EDWIN J. SCHARIO. U. S. 1,814,968, July 14, 1931. A pile or pack of brick, etc., and protective means for the abutting surfaces of all the brick, including a shield for each brick protecting three adjoining surfaces extending from a common corner of the brick. See also *Ceram. Abs.*, **10** [6], 428 (1931).

Imparting a reciprocatory movement to a screen for screening materials or like apparatus. M. P. REYNOLDS. Brit. 349,560, June 10, 1931.

Measuring machines for tile and similar earthenware articles. H. H. HALL AND W. BOULTON, LTD. Brit. 351,791, July 8, 1931.

Kilns, Furnaces, Fuels, and Combustion

Small tunnel kiln for ceramic and metallurgic industries. ANON. *Feuerungstechnik*, **19** [5], 82–83 (1931).—The small tunnel kiln (Kerabedarf, Charlottenburg), designed to meet the needs of the small- and medium-sized plants, works on the same principle as the large tunnel kiln. There are small tunnel kilns in operation which have an interior width of only 0.55 m. and a height of only 0.38 m. over the truck. One kiln heated with gas is 31 m. long and can admit 30 cars of 1 m. length. It is divided into three zones; preheating, sharp firing, and cooling. All types of fuel can be used but gas is preferred. The method of regulating the flame in the burning channel, the control of the draft, and the heat utilization are explained. The economy in fuel amounts to 73% for fine ceramic ware and 70% for heavy. The small tunnel kiln can be used for firing fine and heavy ceramic ware, slag brick and lime, for fusing colors on glass, annealing iron wire, for steel casting, tempering pig iron, firing enamels and electrodes, and for calcining quartz and feldspar. M.V.K.

Small tunnel kilns. ANON. *Ceram. Ind.*, **17** [1], 16–17 (1931).—Small tunnel kilns and their advantages are discussed. Several types are described including direct-fired, muffle, and one twin muffle kiln. Most of the small kilns are of the muffle type. Various methods of carrying the ware through the kiln are described. A small circular kiln is included in the descriptions. W.W.M.

Improvements in kiln and firing arrangements in the enamel industry. JAESCHKE. *Glashütte*, Vol. 61, No. 17–18 (1931); *Feuerungstechnik*, **19** [6], 103 (1931).—The following improvements are discussed: (1) automatic draft regulator, (2) tunnel drying kiln for wet applied enamel, (3) removing of slag, (4) automatic coal feeders for plane and step grate firing, (5) material (Nichrotherm) for recuperators of kilns, (6) conducting fuel gas into muffle kilns, and (7) preventing local overheating in rotary fusing kilns. M.V.K.

New type tunnel decorating kiln. ANON. *Ceram. Ind.*, **17** [1], 60–63 (1931).—The Ajax Electric Co., Inc., Philadelphia, has developed a new type electric-decorating kiln. Unique temperature control is possible. The kilns are made in a number of sizes and of two-way recuperative tunnel, single-way tunnel, circular rotating hearth, and batch kiln types. W.W.M.

Inexpensive electric furnace. ANON. *Elec. Rev.*, **108** [2793], 944 (1931).—An inexpensive electric furnace for temperatures up to 900°C or 1000°C is described. E.P.R.

"Carboradiant" kiln. ANON. *Refrac. Jour.*, **7** [6], 324 (1931).—The Swindell-Dressler Corp., Pittsburgh, has exclusive rights to the "Carboradiant" furnaces. This new departure from the familiar continuous kilns, while open-fired in principle, can be so operated as to make it an intermediate between the muffle and open-fired types. See also *Ceram. Abs.*, **10** [4], 290 (1931). E.P.R.

Zigzag furnace for roofing tile. H. DENDL. *Tonind.-Ztg.*, **55** [42], 613–15 (1931).—A zigzag furnace is advantageous for firing roofing tile. W.M.C.

Progress in methods of drying ceramic ware. VDI BOLANI. *Corriere Ceram.*, **12** [5], 211–18 (1931).—The new drying tunnel "Turbo" (Haas system) which operates on the principle of drying with moist air, is described. M.V.K.

Fuller Lehigh circular burner. ANON. *Pit & Quarry*, **22** [7], 86 (1931).—The Fuller

Lehigh Co. has a pulverized-coal burner of the turbulent type widely used for firing coal. E.P.R.

Gas kilns and producers. ANON. *Tonind.-Ztg.*, **55** [48], 699 (1931).—Different types of gas producers and gas kilns are reviewed. W.M.C.

Kilns for the ceramic industry. E. SCHIRM. *Tonind.-Ztg.*, **55** [35], 505–507 (1931).—Ninety German patents issued for ceramic kilns in 1930 are reviewed. Most of the patents cover kilns for bodies not formed, whereas the rest apply to firing of ceramic products. Tunnel kilns may be fired to temperatures as high as 3600 to 5400°F by means of high frequency. W.M.C.

Comparative fuel cost of different types of kilns. WM. A. BUTLER. *Clay-Worker*, **95** [6], 397 (1931).—Some data on the amount of fuel required on different kilns as observed by B. are presented and discussed. E.J.V.

Raising of chimneys or fans in brick plants. ANON. *Tonind-Ztg.*, **55** [49], 713 (1931).—Advantages and disadvantages of raising of chimneys and of installing fans for brick plants are shortly outlined. W.M.C.

Graphic solution of Euchene's formula. A. ALISON. *Glass*, **8** [3], 100–101 (1931).—The estimation of the requisite contents of the checkers of regenerators is a problem frequently encountered and many empirical formulas have been advanced. Euchene derived a formula relating the heat capacity of the filling with the temperature: $C = 0.20\ T + 0.000062\ T^2$ in which C = the heat in kilocalories stored per kilograms of brick between 0°C and T°C. T = temperature of checker brick in °C. A line chart is given for the solution of this formula and the description and the construction of the chart is explained. The chart is drawn in convenient size for use. H.W.A.

Firing temperatures on glazes. E. BERDEL. *Refrac. Jour.*, **7** [6], 328 (1931); for abstract see *Ceram. Abs.*, **10** [8], 595 (1931). E.P.R.

Thermal potential: the choice of combustibles considered from the viewpoint of calorific effect. HENRY CASSAN. *Chaleur ind.*, **12**, 121–23 (1931). A.J.M.

New theory of natural draft. M. VERON. *Bull. Tech. Soc. Babcock*, No. 10 (1931); *Chaleur ind.*, **12**, 199 (1931). A.J.M.

Thermotechnical possibilities and requirements in the ceramic, especially in the refractory-materials industry. W. BRASS. *Sprechsaal*, **62**, 445–47 (1929).—Thermotechnical conditions in the ceramic industry and their causes are investigated. Good results were obtained in tests carried out on an old chamber oven making use of gas-analytical apparatus. (*C.A.*)

Physics of coal carbonization. S. P. BURKE, T. E. W. SCHUMANN, AND V. F. PARRY. *Fuel*, **10**, 148–71 (1931).—The temperature distributions in (*a*) a flat slab, (*b*) a cylinder, (*c*) a cylindrical annulus, and (*d*) a sphere, the outer surfaces of which are suddenly heated to and maintained at a fixed higher temperature, have been calculated as functions of the time and the thermal diffusivity of the material. The times required to attain a definite distribution of temperature in two geometrically similar bodies are proportional to the squares of their corresponding linear dimensions. It is deduced theoretically that this "law of squares" still holds even when the thermal constants vary with the temperature, and when thermal reactions involving the liberation or absorption of heat occur in the material, provided that such reactions may be regarded as taking place instantaneously. Experiments on crushed coal and coke in cylindrical retorts of different sizes have shown that the laws of conduction for crushed materials deviate by less than 2 to 3% from those for solid materials. The thermal diffusivity of crushed coal (approximately 16-mesh) was 0.010 sq. in./min. (15 to 340°), and of monolithic coke 0.037 sq. in./min. (15 to 540°). The initial part of the curve showing the variation of the temperature at the center of a charge of coal with time is modified by the presence of moisture, heat being transferred through the charge by convection

of water vapor as well as by conduction. Endothermic reactions probably occur during the decomposition of coal in the plastic range, and both endothermic and exothermic reactions subsequently occur on heating the coke. These reactions alter the shape of the heating curve and thus affect to some degree the time of carbonization. Despite the effect of convection and the influence of the time element on the chemical reactions occurring in coal, the "law of squares" is found to hold good for the coking process. (*B.C.A.*)

Low-temperature carbonization. DAVID BROWNLIE. *Queensland Mining Jour.*, **32** [5], 191–92 (1931).—Low-temperature carbonization of coal is at the present time almost completely dead in Germany, except in regard to the "Pintsch" process, and practically the same applies to the U.S. both for coal and shale, largely due to overproduction and price-cutting in petroleum. See also *Ceram. Abs.*, **9** [7], 565 (1930). E.P.R.

Chemical constitution of coal. W. A. BONE. *Chem. & Ind.*, **50** [20], 407–16 (1931).—The origin and formation of coals are discussed. Ultimate analysis of typical products in the wood-coal transformation is shown in a table. The experimental methods employed consist either of (1) the thermal decomposition of the coal, (2) its extraction by some selected sequence or combination of solvents, or (3) some chemical attack upon it. The results of these tests are given in tables and are fully discussed. G.R.S.

Mechanism of the combustion of powdered coal. A. GREBEL. *Chaleur ind.*, **12**, 126–34 (1931); see also *Ceram. Abs.*, **10** [6], 453 (1931). A.J.M.

Calculating the heat value of coal from the water and ash content. FRITZ G. HOFFMANN. *Feuerungstechnik*, **19** [6], 89–91 (1931).—The heating value of a definite coal is always related to a definite water and ash content; it rises and falls with their changes in a regular manner conditioned by the heat of vaporization of the water. Formulas are given for calculating the heating value of wet, dry, and pure coal, and their dependence on the amount of the water and ash content is explained. A diagram shows the numerical values for practical use. M.V.K.

Under-water storage of coal. ANON. *Engineering*, **131** [3408], 616 (1931).—Work of J. H. A. Nicolls, published among the investigations on fuel and fuel testing at the Testing and Research Laboratories of the Canadian Dept. of Mines, is discussed. A.A.

Use of pulverized coal. A. S. WILLIS. *Mech. World*, **89** [2313], 414–15 (1931).—The use of pulverized coal is not gaining favor in this country as quickly as was first expected. W. discusses the advantages and disadvantages and the faults and possible corrections of the present installations. E.P.R.

Firing round porcelain kilns with coal gas. ANON. *Gas und Wasserfach*, **73**, 1066–74, 1090–96 (1930); *Refrac. Jour.*, **7** [4], 264 (1931).—A detailed account is given of the practical methods adapted and of the theoretical considerations involved in converting two coal-fired porcelain ovens to gas firing. The work was divided into three phases: (1) investigations of a coal-fired oven, (2) theoretical considerations before changing over to gas firing, and (3) investigations of a gas-fired oven. The method of obtaining the necessary data for compiling thermal balances is explained and discussed. E.P.R.

Natural gas. J. L. SCOTT. *Clay-Worker*, **95** [6], 396–97 (1931).—A few notes on the use of natural gas in the flashing and glazing of clay products are presented with some precautionary measures to be observed in any use of the gas as fuel. Illustrated. See also *Ceram. Abs.*, **10** [8], 594 (1931). E.J.V.

Amount of heat available in combustion gases for artificial drying. G. SCHULZ. *Tonind.-Ztg.*, **55** [44], 644–45 (1931).—The importance of evaluating the amount of heat from combustion gases in calculating the price of coal is emphasized. W.M.C.

Thermal conductivity of gases. M. TRAUTZ AND A. ZUENDEL. *Z. tech. Physik*, **12** [6], 273–84 (1931).—This paper gives a complete compilation of methods and results concerning the thermal conductivity of gases as a function of temperature, including values for air, hydrogen, and carbonic acid gas. W.M.C.

Automatically controlled slow cooling and heating. G. OWEN. *Chem. & Ind.*, **50** [22], 190 (1931).—Regulation of the flow of gas by means of a small aspirator will give either a slow rise or fall in temperature at the gas burner. Arrangement of the aspirator is shown in a diagram. G.R.S.

Use of fuel oil for firing heavy ceramic products. L. A. MIKLER. *Fuels & Fur.*, **9** [3], 351–56 (1931).—All fuel oil can be divided into two main groups: the overhead or distillate fuels and the residual fuels. Fuel oils are generally classified according to gravity but such comparisons alone may prove misleading. Calorific value, viscosity, flash point, reaction to "pour test," degree of suspended solid matter, water, and sulphur content must all be considered when choosing a fuel oil. In the ceramic plant, the selection of a fuel oil should be determined by the particular heat application. Heavy fuel can be burned under boilers satisfactorily but when heating is a direct part of a manufacturing process the lighter grades may prove more economical. The burning of the heavier fuel is sometimes harder to control with a resulting production of more seconds. Many fuel oils are substandard in one or more respects, but these oils can be used satisfactorily by manufacturers of certain types of ware without having the products affected. As these substandard fuels are cheaper, a considerable saving can be made in operating costs by their use. A comparatively new fuel, "low level-cracked residuum and flashed-cracked residuum" is being used by a number of ceramic manufacturers. It can best be used in a power plant and in continuous kilns. A.E.R.W.

Origin of petroleum, related hydrocarbons, and some coals. KRUSCH. *Tech. Blätter*, Nov. 24; *Queensland Mining Jour.*, **32** [5], 182–83 (1931).—K. advances a theory which seems to combine some of the older theories with the new. Petroleum occurs with different compositions and its occurrences are different. He gives a review of possible origins of petroleum. E.P.R.

BOOKS

Gas Installations and Appliances. A. T. GILBERT. Crosby Lockwood & Son, London, 1931. *Mech. World*, **89** [2318], 540 (1931).—G. has given in a concise and simple manner, explanations of the principles on which present-day practice is based. E.P.R.

Calculations in Heating Technology. (Feuerungstechnisches Rechnen.) WILHELM GUMZ. 133 pp., 62 figures. Published by Otto Spamer, Leipzig. Reviewed in *Chaleur ind.*, **12**, 202 (1931). A.J.M.

Flow and Measurement of Air and Gases. A. B. EASON. *Mining & Met.*, **12** [295], 14 (1931); see also *Ceram. Abs.*, **10** [8], 595 (1931). E.J.V.

PATENTS

Ceramic furnace. JOSEPH A. DEDOUCH. U. S. 1,811,307, June 23, 1931. A ceramic furnace having a heating chamber, and a reciprocable frame having work-supporting stands extending entirely through the heating chamber.

Tunnel kiln. ARTHUR MCDOUGALL DUCKHAM. U. S. 1,814,906, July 14, 1931. In tunnel kilns, a device for ensuring that the normal width of the traveling platform or its equivalent will not be exceeded so as to prevent its smooth reëntry into the tunnel, consisting of surfaces disposed at opposite sides of the platform and spaced to smooth out or replace by pressure any parts of the platform projecting laterally beyond the normal width thereof.

Fans suitable for induced-draft installations. SCHMIDT'SCHE HEISSDAMPF-GES. Brit. 350,859, June 24, 1931.

Rotary annular plate oven for carbonization of coal. KOHLENSCHEIDUNGS GESELLSCHAFT M.B.H. Ger. 506,541; *Gas Age-Rec.*, **68** [1], 35 (1931).—An oven made in the form of a rotary annular plate and employed both for drying as well as carbonizing coal is described. E.J.V.

Continuously operating coke oven. JOHANN LUETZ. Ger. 507,788; *Gas Age-Rec.*, **68** [1], 35 (1931).—The feature of this coke oven is a movable bottom which can be raised and lowered at will and on which the charge rests. E.J.V.

Brick kiln. BORNKESSEL & CO. M.B.H. Ger. 516,950, Feb. 13, 1929. Details of fuel loading are given. (*C.A.*)

Channel ceramic furnace. F. A. MEINGARD. Russ. 19,519, Feb. 28, 1931. (*C.A.*)

Geology

Determining extension and quality of clay pits. ANON. *Tonind.-Ztg.*, **55** [51], 738–41 (1931).—A short outline is given on methods for making the necessary borings to get an idea about the amount of clay present. Then a small pit should be made and samples obtained to determine the quality of the raw material present. The importance of taking samples from car loads with clay, etc., is outlined and a practical tool for this purpose is described. W.M.C.

Modern technique in the investigation of opaque minerals and ores. F. C. PHILLIPS. *Sci. Prog.*, **25**, 633–41 (1931).—The study of opaque minerals, as distinct from those which are transparent in thin sections, was begun by Campbell at Columbia (1906) and has now reached great significance. The subjects dealt with are reflecting power anisotropism, electrical conductivity, etchability, etc. H.H.S.

Potash from silicate rock. P. H. ROYSTER. *Chemicals*, **35** [20], 8 (1931).—A discussion is given of the various methods used in extraction of potash from green sands and silicate rocks. Reports on the experiments of volatilizing the potash from the molten rock indicate that this method may replace the usual mode of extracting the potash from water solutions. G.R.S.

Composition and uses of bentonite. H. T. COSS. *Brit. Clayworker*, **40** [469], 76–78 (1931).—A general discussion, tests, and specifications for satisfactory material are given. Its uses in structural clay products, refractories, pottery, and enamels are reviewed. R.A.H.

Geology of dolomite. W. MORITZ. *Tonind.-Ztg.*, **55** [44], 645–47 (1931).—The natural sources for dolomite are reviewed and the theories of forming the dolomite layers are discussed. W.M.C.

Canadian prairie provinces survey clay deposits. ANON. *Christian Sci. Mon.*, **23** [181], 10 (1931).—A survey of the coal and clay deposits lying north of the Saskatchewan River in the Swift Current area has been instituted by the Provincial Government. E.J.V.

Synthesis of silicates. W. EITEL. *Forschungen und Fortschritte*, Nov., pp. 407–408 (1930); *Giorn. chim. ind. applicata*, **13** [1], 27–28 (1931); for abstract see *Ceram. Abs.*, **10** [5], 380 (1931). M.V.K.

Clay in soil profile development. G. W. ROBINSON. *Jour. Agric. Sci.*, **20**, 618–39 (1930); *Sci. Prog.*, **25**, 598 (1931).—Development of soil profile is studied by the character of the clay fraction. The data indicate the general tendency for sesquioxides to be removed from the surface soil and deposited in lower layers. Horizons of podsolic profile are clearly distinguished by the SiO_2:R_2O_3 ratio of the clay fraction. H.H.S.

BOOKS

Elementary Economic Geology. HEINRICH RIES. John Wiley & Sons, Inc. *Pit & Quarry*, **22** [6], 77 (1931).—This book is written for engineers. There are 185 pages devoted to nonmetallics, cover coals, petroleum, natural gas, building stones, clay, limes, calcareous cements, salines, gypsum, fertilizer minerals, abrasives, asbestos, fuller's earth, graphite, lithographic stone, magnesite, mica, paint minerals, monazite, and precious stones. This volume is a condensation of a much larger and more comprehensive textbook by the same author. E.P.R.

Economic Geology. HEINRICH RIES. 6th ed., revised. John Wiley & Sons, N. Y. 860 pp. $6. Reviewed in *Econ. Geol.*, **25**, 230 (1930). (*C.A.*)

Elements of Engineering Geology. HEINRICH RIES AND THOMAS L. WATSON. John Wiley & Sons, Inc. *Pit & Quarry*, **22** [6], 77 (1931).—The 2nd edition of this book includes new chapters on the geology of reservoirs and dam sites and historic geology. E.P.R.

Chapters on the Geology of Scotland. B. N. PEACH AND J. HORNE. xvi + 232 pp., 18 plates, 27 figures. Oxford Univ. Press, 1930. Price 10s 6d. Reviewed in *Sci. Prog.*, **25**, 716–17 (1931). H.H.S.

Chemistry and Physics

Study of the influence of hydrolysis temperature on some properties of colloidal ferric oxide. I. Particle size. G. H. AYRES AND C. H. SORUM. *Jour. Phys. Chem.*, **34** [4], 875–85 (1930).—Ferric oxide sols were prepared by hydrolysis of ferric chloride solutions at temperatures between 100 °C and 145 °C. The particle size of these sols was determined by direct particle count, and found to range from 52 to 76$\mu\mu$, the mean size being 60$\mu\mu$. The particle size was not influenced by the temperature of preparation or concentration of reagents. **II. Stability.** *Ibid.*, **34** [11], 2628–35 (1930).—The flocculation values of sols prepared at different temperatures show no regular variation with the temperature. Samples of stock sols, after heating to various temperatures, are less stable toward a flocculating electrolyte, the higher the temperature of heating. High temperatures produce sols of a red-orange color, the liquids being also opaque and showing considerable settling on standing. The colors and turbidity observed indicate a less hydrous oxide at higher temperatures, such oxide being less stable toward electrolytes than the dispersed phase present in sols made at lower temperatures. The decrease in stability and the increase in turbidity by increasing temperature is not due to an increase in the particle size. **III. Viscosity and hydration.** *Ibid.*, **34** [12], 2826–40 (1930).—Viscosities of sols prepared at various temperatures were measured and found to decrease with increasing temperature of preparation. Samples of stock sols heated to various temperatures show lower viscosity and lower flocculation value the higher the temperature to which they were heated. Complete precipitation was effected at temperatures of 170 °C and 190 °C. The relative viscosity and also the flocculation value of the sols were found to decrease on the addition of alcohol and acetone. Hydration is a stability factor in the ferric oxide sols studied. **IV. Variation of density and relative viscosity with sol concentration.** *Ibid.*, **35** [1], 412–16 (1931).—The density of ferric oxide sols varies linearly with the concentration of the dispersed phase, but is not influenced by the temperature of preparation of the sol. No generalization can be drawn regarding the shape of the viscosity-concentration curve, even at low concentrations of dispersed phase, *e.g.*, up to 0.5%. In some cases the relation is linear, while in others the curve is slightly or markedly convex toward the axis of concentration. G.R.S.

Relation of melting point energy to absolute temperature. Z. HERRMANN. *Z. anorg. allgem. Chem.*, **198** [1], 204–205 (1931).—The melting point energy is that energy which

must be given to a gram atom of an element to raise its energy from that at absolute zero to that in the liquid state. According to H., this energy is proportional to the absolute temperature where the proportionality constant is about 8. L.T.B.

Study of ceramic products by means of physical tests and petrographic examinations. F. CHALAMEL. *Céramique*, **34** [517], 73–79 (1931).—C. describes briefly the function of a polarizing microscope and presents a table giving the results of physical tests and petrographic examinations of a number of stoneware and terra cotta tile. It is shown that (1) the quartz grains in the stoneware show more solution; (2) few and small quartz grains indicate low porosity, high crushing strength, and low wear resistance; (3) the grain size of the clay bond is not as important as that of the quartz, but a fine grain size increases crushing strength; (4) sillimanite ($Al_2O_3SiO_3$) is the principal characteristic of a vitrified body; it is not found in terra cotta but is found in four forms in stoneware: the granular, bead-like, elongated, and needle-like forms; (5) the presence of needle-like sillimanite overcomes the defects caused by large quartz grains; and (6) small pores give better products. In order to avoid the needle-like form of sillimanite which may cause deformation, active fluxes should not be used. Only granular, bead-like sillimanite should be formed and the desirable physical properties may be secured by mixing thoroughly and pressing at high pressures so that small voids and few grains of quartz are found in the finished product. A.E.R.W.

Theory of recrystallization. J. A. M. VAN LIEMPT. *Z. anorg. allgem. Chem.*, **195** [4], 366–86 (1931).—A mathematical treatment of recrystallization is presented. This theory is limited solely to the "active recrystallization." The secondary phenomenon of surface recrystallization as well as Tammann's "intermediate substance" theory is unchanged and can be added to complete the picture. By assumptions regarding the vibration of the atoms, the crystalline structure, and the temperature, L. derives expressions for the rate of diffusion of one material into another (1) when the materials have a similar structure, (2) when one of the materials is deformed, as in "worked" metals, and the other has a normal structure, and (3) for materials crystallizing in different systems. Besides the mathematical treatment, a mechanical picture of recrystallization is supplied. L.T.B.

Micromethod for measurement of surface tension. H. MONQUIN AND S. NATELSON. *Jour. Phys. Chem.*, **35** [7], 1931–34 (1931).—The method is described in detail. The apparatus and technique are so simple as to make it universally applicable. The accuracy obtained with it equals that of any of the current micromethods. G.R.S.

Use of the ultramicroscope for observing smoke particles falling on liquid films. P. D. WATSON AND A. L. KIBLER. *Jour. Phys. Chem.*, **35** [7], 2125–28 (1931).—The method consists of focusing a microscope vertically upon a horizontal liquid film which is illuminated by a beam of light focused upon it at an angle of 45°. G.R.S.

Measuring hydrogen-ion concentration. C. H. S. TUPHOLME. *Mech. World*, **89** [2316], 485–86 (1931).—Control of alkalinity and acidity by means of p_H measurement has come into extensive use in most industries, and the importance of p_H in the corrosion of metals is now well known. The importance of hydrogen-ion control in the chemical treatment of boiler feed water is apparent. The two chief methods of determining the p_H value of any solution are the electrometric and the colorimetric. The electrometric method is particularly convenient for determining the effective acidity or alkalinity of a solution and is based on the fact that the hydrogen and hydroxyl ions are known to carry definite positive or negative charges. Simple apparatus and its operation are described. The principle of determining the p_H of a solution by the colorimetric method is based on the fact that various indicators change in color when they are acted upon by solutions of different acidities or alkalinities. The simplest and best-known form of this method is litmus paper. E.P.R.

Control methods in chemical industry. G. A. PERLEY. *Chem. & Ind.*, **50** [22], 452–60 (1931).—Factors requiring control are temperature, pressure, humidity, composition as applied to the gas phase as well as to hydrogen-ion concentration, weight and volume, flow, specific gravity, liquid level, and even time. Indicating, recording, and automatic control equipment are discussed. Particular attention is given to electrical installations. G.R.S.

Source of error when measuring thermal expansions of ceramic materials by means of the tube method. W. STEGER. *Sprechsaal*, **64** [19], 351–54 (1931).—In many cases, the expansion behavior of ceramic materials is determined by means of the so-called tube method. The sample to be tested is placed in a quartz tube and the difference between the expansion of the sample and of a piece of quartz of the same length is measured. Errors may arise as the result of differences in temperature of the outer quartz tube and the sample. Some curves are given to illustrate this. Thin samples and thin quartz tubes should be used to avoid this source of error. The temperature should be measured always at the quartz tube and at the sample. The temperature should be raised slowly and the heating current should be regulated without steps. W.M.C.

Preparation of Debye-Scherrer patterns of alloys which are affected by the presence of air. E. ZINTL, A. HARDER, AND S. NEUMAYR. *Z. phys. Chem.*, **154***A* [1], 92–96 (1931).—A method is described for the powdering and filling of capillary tubes for X-ray powder photographs of oxidizable or hygroscopic materials. L.T.B.

Gas permeability of ceramic materials at high temperatures. ANON. *Tonind.-Ztg.*, **55** [40], 589 (1931).—A review of the literature is given together with a discussion of the laws governing the gas permeability of ceramic materials at high temperatures. W.M.C

Separation of continuous solid solution series. G. TAMMANN AND A. RUPPELT. *Z. anorg. allgem. Chem.*, **197** [1], 65–89 (1931).—Many Na and K salts crystallize from their melts as continuous solid solutions. These solutions are clear but separate on cooling and then become cloudy. In many of the solid solutions the cloudiness is preceded by an opalescence. Among the compounds which show this separation are the Na and K feldspars. To obtain a homogeneous solid solution again, the materials must be reheated. From X-ray studies it was found that perthite only becomes homogeneous after heating to 1100°C. On slow cooling separation again follows. In general no separation takes place if Δa is 0.047 Å; on the other hand, separation will take place when Δa is only 0.054 Å. $\Delta a = \frac{d_A - d_B}{\frac{a_A + a_B}{2}}$ where a_A and a_B = the parameters of the components. L.T.B.

Studies on kaolin. ROBERT SCHWARZ AND WILHELM KLOS. *Z. anorg. allgem. Chem.*, **196** [2], 213–19 (1931).—Dilatometric measurements were made on kaolin when heated from 20 to 1000°C. After the loss of water the kaolin shows a regular expansion to a temperature of 582°C. There follows a contraction due to the loss of water of constitution. There are two breaks at 846°C and 938°C. The first corresponds to a decomposition of the metakaolin, $Al_2O_3 \cdot 2SiO_2$, and the second to the beginning of mullite formation. The linear expansion of various high-fired kaolins was measured and the linear coefficient of expansion was calculated. Dilatometric studies were made on rehydrated kaolin, *i.e.*, metakaolin which has lost its water of constitution but which has not been heated above 850° so that it can be rehydrated. When kaolin is mixed with Norwegian feldspar and heated, a contraction sets in at 582°; this contraction takes place at the same temperature as in pure kaolin but is not as pronounced. At 850° there is a slight expansion; at 940° a marked contraction begins. Mixtures of equal amounts of kaolin, feldspar, and alumina behave similarly. Quartz-kaolin mixtures in equal amounts were also studied. L.T.B.

Method for the analytical determination of small amounts of alkalis in water-insoluble acids. G. HEYNE. *Z. angew. Chem.*, **44** [18], 328–29 (1931).—A small amount of alkali in water-insoluble acids such as silicic, tungstic, or zircon acid, can only be determined with great difficulty. In some cases, *e.g.*, silicic acid, the acid can be volatilized, but there is always danger of loss of alkali. H. reports an electrodialysis method whereby, in an aqueous paste under the influence of an electric field, electrolyte wanders to the electrodes while the material to be purified is retained by the diaphragm. The special apparatus constructed is described. L.T.B.

Internal friction of fluid media. N. GERASIMOV. *Phys. Z.*, **32** [11], 444–50 (1931).—Equations for calculating the internal friction of fluid media are derived and a method for determining the size of molecules is discussed. The dependence of the heat of combustion on the viscosity is pointed out. W.M.C.

Thermometric lag. ANON. *Instrument World*, **3**, 260 (1931).—Since the time curve of two bodies after contact reaching the same final temperature is logarithmic, a thermometer is tested for lag over the range obtained by dividing the initial difference of temperature by 2.718 (the lag base *e*). The time, in seconds, taken by the thermometer to reach this intermediate temperature is known as its lag coefficient. H.H.S.

System Pb'' oxide–H_2O. GUSTAV HÜTTIG AND BELA STEINER. *Z. anorg. allgem. Chem.*, **197** [3], 257–69 (1931).—X-ray studies and dehydration isobars were made on a series of preparations in this system. The authors conclude that one hydrate, PbO·-$^1/_2$ H_2O, is formed. L.T.B.

System Fe'' oxide–H_2O and its change to the system Fe''' oxide–H_2O. GUSTAV HÜTTIG AND HERBERT MOLDNER. *Z. anorg. allgem. Chem.*, **196** [2], 177–87 (1931). L.T.B.

Studies for the determination of the melting diagram of the system Al_2O_3–Cr_2O_3–MgO. KARL J. A. BONTHRON AND ROBERT DURRER. *Z. anorg. allgem. Chem.*, **198** [1], 141–56 (1931).—These studies include melting-point determinations on various oxide mixtures in the system but no crystallographic studies. The studies were made in a furnace heated with an acetylene blast. Temperatures were measured with a micropyrometer and melting points between 1900° and 2550° were determined. The results are given as isotherms on a three-component diagram. There is at least one eutectic in the system Al_2O_3–Cr_2O_3 and possibly two. MgO and Cr_2O_3 form two compounds: $2Cr_2O_3$·MgO and Cr_2O_3·MgO. Two ternary eutectics were found. No well distinguished maxima which might indicate ternary compounds were detected in the system. L.T.B.

Densities of molten cryolite and of a molten mixture of cryolite and barium fluoride. N. KAMEYAMA AND A. NAKA. *Chem. News*, **142** [3711], 339 (1931).—Densities were determined by means of loss of weight of a platinum sphere suspended in the molten material by means of a long platinum wire attached to one arm of a chemical balance. The following results were obtained:

BaF_2 in melt					
Weight (%)	0	21.8	50.0	62.5	71.6
Molar (%)	0	25.0	54.4	66.6	75.1
Density gram/cc.	2.03	2.37	2.91	3.19	3.74
Specific vol. cc./gram	0.49	0.42	0.34	0.32	0.27
Molecular vol. cc./gram molecule	103	84.8	65.8	58.7	49.3
Density gram/cc.					
1005° C		2.41	2.94	3.23	3.77
1057		2.37	2.91	3.18	3.73

G.R.S.

Separation of beryllium from aluminium. A. TRAVERS AND J. SCHNOUTKA. *Compt. rend.*, **192**, 285–87 (1931); *Analyst*, **56**, 273 (1931).—The freshly precipitated hydroxides

are dissolved in excess of alkali and the solution is saturated with SO_2, boiled for 10 min. and left in the cold for some hours. Al_2O_3 is precipitated quantitatively. H.H.S.

Data on the determination of boric acid. G. VASTAGH. *Magyar Chem. Folyóirat*, **37**, 55–71 (1931).—The titration of H_3BO_3 in neutral solutions containing 1% of mannitol was studied. Acids (except H_3PO_4 and SiO_2) do not interfere if neutralized previously with KOH in the presence of methyl red. It was found that 2 distillations with H_2SO_4 and MeOH served to remove H_3BO_3 from cations; 0.06 mg. of H_3BO_3 could be detected in 2 g. of $Al_2(SO_4)_3$ crystals. The macro- and micro-chemical determination of H_3BO_3 is described in detail. (*C.A.*)

Colorimetric determination of small amounts of titanium. H. GINSBERG. *Z. anorg. allgem. Chem.*, **198** [1], 162–67 (1931).—The method described is for the determination of amounts of titanium less than 0.5%. L.T.B.

X-ray studies on orthotitanates. SVEN HOLGERSSON AND ADOLF HERRLIN. *Z. anorg. allgem. Chem.*, **198** [1], 69–78 (1931).—The orthotitanates of Mg, Co, Zn, and Mn were made synthetically. X-ray studies show that these orthotitanates belong to the spinel type. The lattice constants for these compounds are given. L.T.B.

Structure of silica gel (X-ray study). LAURA KREJCI AND E. OTT. *Jour. Phys. Chem.*, **35** [7], 2061–64 (1931).—Pure precipitated silica was shown to be entirely transformed into the crystallized state by heating to 1150°C for 5 hr. The crystals obtained are of the cristobalite modification. Precipitated silica samples which are never heated above 500°C show distinctly the presence of crystalline centers of colloidal dimensions. The same is true for a freshly prepared sample which is at no time heated above 100°C. The X-ray patterns of these silica gels are apparently identical and indicate the crystals to be of the cristobalite type. G.R.S.

Heat of formation of silicic hydrates. P. A. THIESSEN AND O. KOERNER. *Z. anorg. allgem. Chem.*, **197** [3], 307–12 (1931).—Vapor pressure curves were determined for various silicic acids, $SiO_2 \cdot 2H_2O$, $2SiO_2 \cdot 3H_2O$, $SiO_2 \cdot H_2O$, $2SiO_2 \cdot H_2O$ The course of these curves serves as a means of comparison of the stability of the hydrates. Those hydrates which contain the greater amounts of water are the least stable. The molecular heat of combination of the water in the hydrates can be calculated from the increase of the vapor pressure. It amounts to 1.2 to 1.5 kg. cal., and accordingly is lower than that for many other crystal hydrates. This lower heat of combination explains the relative instability of these hydrates when heated or dried. L.T.B.

Identification of silicic acids and silicates. F. W. MEIER AND LUDWIG SCHUSTER. *Z. anorg. allgem. Chem.*, **196** [2], 220–24 (1931).—The solubility of SiO_2 in caustic and in alkali carbonate solutions was determined. L.T.B.

Reduction reactions in silica gels. D. DEDRICK. *Jour. Phys. Chem.*, **35** [6], 1777–83 (1931).—A study was made of the reduction of cupric ions in silica gels. G.R.S.

Molecularly dispersed SiO_2 and TiO_2. H. BRINTZINGER AND W. BRINTZINGER. *Z. anorg. allgem. Chem.*, **196** [1], 44–49 (1931).—It has been found that on treatment of silicic acid tetramethyl ester with $N/100$ HCl, a molecularly dispersed material was obtained which on aging condensed to larger molecules. The molecular weights were determined by cryoscopic methods. With $N/500$ HCl a uniform silicic acid was obtained of composition $2SiO_2 \cdot 2H_2O$. This changes to $4SiO_2 \cdot 3H_2O$ and then to $8SiO_2 \cdot 4H_2O$. A stable silicic acid of molecular weight 8260 was found. TiO_2 can also be formed in a dispersed state which rapidly condenses to a higher form. L.T.B.

Rapid titrometric method for the determination of manganese in ores and metal alloys. I. MAJDEL. *Arhiv za Hemiju i Farmaciju*, **5** [2], 45–49 (1931).—This rapid quantitative method is described in detail. E.J.V.

Rapid volumetric determination of CO_2 in carbonates. THEODORE HECZKO. *Z. angew. Chem.*, **44** [4], 85–86 (1931).—In the determination of CO_2 in carbonates the

sample is covered with a layer of V_2O_5. At high temperatures vanadates are formed while CO_2 is expelled. L.T.B.

Sodium oxide. E. ZINTL AND H. H. v. BAUMBACH. *Z. anorg. allgem. Chem.*, **198** [1], 88–101 (1931).—Two methods of preparing pure sodium oxide from $NaNO_3$ and NaN_3 are given. An X-ray powder photograph of Na_2O showed that it crystallizes in the cubic system with a fluorite structure. Crystal structure measurements are given. The chemical behavior of Na_2O toward O_2 and N_2 was studied. L.T.B.

Density of sulphur dioxide. D. L. COOPER AND O. MAASS. *Can. Jour. Research*, **4** [5], 495 (1931).—The density of sulphur dioxide has been measured and equations of 5 isothermals are given. Some evidence of adsorption influence appears in the isothermal at −7.82°C. The normal density of sulphur dioxide found is 2.9262. W.L.

Conductivity of ZrO_2. HANS SCHWEITZER. *Z. angew. Chem.*, **44** [4], 151–52 (1931).—The conductivity in reciprocal ohms was measured between 200° and 800°, and values reported. In samples containing MgO the conductivity decreased as the amount of MgO decreased. S. could not measure the conductivity of pure molten ZrO_2 directly, but he believes that it is considerably smaller than that of molten quartz. L.T.B.

Relation of the previous history of ZnO to its ability to adsorb organic dyes. GUSTAV F. HÜTTIG AND WALTER NEUSCHUL. *Z. anorg. allgem. Chem.*, **198** [1], 219–32 (1931).—The authors report some studies on the change in the adsorptive properties of Al_2O_3-hydrate on aging. L.T.B.

Study of the flocculation of a sodium clay soil. E. MCK. TAYLOR AND R. M. WOODMAN. *Chem. & Ind.*, **50** [24], 203–206 (1931).—When flocculation has been accomplished by a concentrated solution of calcium sulphate or hydroxide, it can be maintained as long as any water in contact with the sediment contains a small percentage of these substances. Hydrolysis to give an alkaline medium is proved to take place at the same time as the initial flocculation. This flocculation was proved not to be due to base exchange. G.R.S.

Classical methods of analysis of silico-aluminous, calcareous, alkaline materials (rocks, brick, bauxites, slags, glasses, and siliceous minerals). J. DEFORGE. *Bull. soc. chim. Belg.*, **39**, 539–50 (1930).—The difficulties encountered in the analysis of these materials after attack by alkali carbonates or by hydrofluoric acid are discussed. The hydrofluoric acid method is preferred and details are given of an improved technique for this purpose. Comparative analyses obtained by the two methods are given.

(*B.C.A.*)

BOOKS

Radiations from Radioactive Substances. ERNEST RUTHERFORD, JAMES CHADWICK, AND C. D. ELLIS. 588 pp. Macmillan Co., New York. Reviewed in *Jour. Phys. Chem.*, **35** [6], 1805–12 (1931).—Important topics treated are as follows: radioactive transformations, the alpha rays, absorption of alpha rays, some properties of the alpha rays, secondary affects produced by alpha rays, theories of absorption of alpha rays and general properties of the radiations, the scattering of alpha and beta particles with light atoms, the artificial disintegration of the light elements, the radioactive nuclei, the disintegration of electrons, the scattering and absorption of gamma rays, intensity problems connected with the emission of gamma rays, and atomic nuclei. G.R.S.

Monograph of Viscometry. GUY BARR. University Press, London, England. Price $12.00. *Mining & Met.*, **12** [295], 12 (1931).—In this book devoted entirely to viscometry, eight of the eleven chapters are devoted to the viscous flow of liquids, tube viscometers for absolute measurements, commercial absolute viscometers, capillary viscometers for relative measurements, the transpiration of gases, the falling sphere method, rotational and oscillational viscometers, and miscellaneous methods. E.J.V.

Applied Mathematics for Engineers. Vol. III. T. HODGSON. Chapman & Hall,

Ltd., London. *Elec. Rev.*, **108** [2793], 948 (1931).—In the previous volumes of this series H. has dealt with graphical statics, and the rudiments of the calculus, illustrated with reference to problems in dynamics. The present volume is devoted to the more elementary forms of differential equations. The elementary treatment of exact equations is illustrated by simple problems in thermodynamics. Linear differential equations with constant coefficients are treated in the usual way, and the work is illustrated by problems in alternating-current theory and in the theory of struts. E.P.R.

Infra-Red Analysis of Molecular Structure. F. I. G. RAWLINS AND A. M. TAYLOR. 176 pp. The University Press, Cambridge, and the Macmillan Co., New York. Reviewed in *Jour. Phys. Chem.*, **35** [6], 1821–24 (1931). G.R.S.

Spectrum Analysis of Mineralogy. A. A. FITCH. 52 pp. Reviewed in *Chem. News*, **142** [3712], 366 (1931); *Mining & Met.*, **12** [295], 12–14 (1931); for abstract see *Ceram. Abs.*, **10** [8], 608 (1931). G.R.S.

Textbook of Practical Physical Chemistry. K. FAJANS AND J. WÜST. E. P. Dutton Co., New York. 233 pp. Price $4.95. Reviewed in *Jour. Phys. Chem.*, **35** [7], 2142–44 (1931); for abstract see *Ceram. Abs.*, **10** [8], 608 (1931). G.R.S.

Modern Physics. THEODOR WULF. E. P. Dutton & Co., New York, 1930. *Mech. World*, **89** [2317], 519 (1931); for abstract see *Ceram. Abs.*, **10** [1], 75 (1931). E.P.R.

Construction Materials Handbook (Baustoff Praktikum). H. NITZSCHE. Max Jänecke, Leipzig. Price 1.60 M. *Z. angew. Chem.*, **44** [10], 190 (1931).—This book is divided into three parts: (1) important chemical reactions of construction materials, (2) chemistry of construction materials, and (3) mechanical properties of construction materials. The book is poorly printed with many typographical errors. L.T.B.

Physical Properties of the Soil. BERNARD A. KEEN. Reviewed in *Jour. Phys. Chem.*, **35** [6], 1812–17 (1931); for abstract see *Ceram. Abs.*, **10** [8], 608 (1931). G.R.S.

PATENTS

Manufacture of titanium preparations. I. G. FARBENINDUSTRIE AKT.-GES. Brit. 348,724, May 28, 1931; see also *Ceram. Abs.*, **9** [8], 681 (1930).

Decomposing ores of zirconium. DEUTSCHE GASGLÜHLICHT-AUER-GES. Brit. 350,728, June 24, 1931.

Manufacture of titanium dioxide. METAL & THERMIT CORP. Brit. 351,841, July 8, 1931.

General

Specific gravity and porosity of kaolins after firing. ANON. Bur. Stand., *Tech. News Bull.*, No. 169, p. 53 (1931).—These properties are given of North Carolina, Delaware, Georgia, Zettlitz, and English china clay after firing at 6 different temperatures ranging from 1150 to 1500°C. R.A.H.

Controlling a control system. DONALD HAGAR. *Ceram. Ind.*, **17** [1], 30–38 (1931).—H. stresses the importance of proper control in plants. In his organization chart he places the control engineer on a level with the plant superintendent and directly responsible to the production manager. He outlines a system of control for a floor and wall tile plant which can be modified for other plants. Control of and tests for raw materials, clay preparation, forming, firing, glazes, preparation, and application of both colored and white, and grinding of glaze materials are included. W.W.M.

Progress of power production. ANON. *Engineering*, **131** [3408], 611–12 (1931). A.A.

Nonstructural figures on glass qualify as trade marks. WALDON FAWCETT. *Glass Ind.*, **12** [7], 143 (1931).—As the result of a decision by the Patent Commissioner, figures of marking media which are not serving any function on the glass object other than as a mark may be registered as trade marks. The specific case involving this decision is discussed. E.J.V.

Composition and properties of some explosives for the lime and cement industries. J. DEFORGE. *Rev. mat. constr. trav. pub.*, No. 254, pp. 440–46 (1930); see also *Ceram. Abs.*, **10** [2], 154 (1931). A.J.M.

Economics of the nonmetallic mineral industries. V. Finding markets. RAYMOND B. LADOO. *Rock Prod.*, **34** [14], 30–31 (1931).—L. deals with market surveys, their importance in judging the possibilities of success of a new enterprise or a new product, and how to go about getting such a survey. For Part IV see *Ceram. Abs.*, **10** [8], 609 (1931). W.W.M.

Associational effect creates large market for clay products. ANON. *Clay-Worker*, **95** [6], 388–89 (1931).—Through the efforts of the Southwest Clay Products Institute, thousands of tons of clay products are being used in the construction of Randolph Field, the government flying field at San Antonio, Texas, instead of the previously specified monolithic concrete. Illustrated. E.J.V.

Chemical research urged as step in remedying economic conditions. ARTHUR D. LITTLE. *Amer. Glass Rev.*, **50** [34], 15 (1931).—Intensive chemical research for better control of processes, improvement of products, and of new products to create new wants was advocated in an address by L. E.P.R.

Plans laid for Materials and Equipment Division. ANON. *Nat. Glass Budget*, **47** [8], 22 (1931); for further details see *Bull. Amer. Ceram. Soc.*, **10** [7], 257 (1931). E.P.R.

Panorama of clay research at Ohio State. J. O. EVERHART AND C. R. AUSTIN. *Brick Clay Rec.*, **78** [13], 700–702 (1931).—A progress report, covering the period from Feb. 15 to April 15, on various research projects at the Roseville Station is presented. E.J.V.

School training. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **10** [7], 195–97 (1931).—It is pointed out that schools can merely give training in the acquisition of facts, but the potentiality to use the facts must be inborn. Particular mention is made of those who have succeeded through a development of their potentialities even though they have not had collegiate training. E.J.V.

Ohio is honored by a few of her early graduates. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **10** [7], 197–98 (1931).—The granting of the degree of Ceramic Engineer at O.S.U. is commended but a suggestion is offered that it be granted as an honor rather than as the result of application for it. E.J.V.

Century of Progress in ceramics. ANON. *Nat. Glass Budget*, **47** [8], 12 (1931).—The ceramic industry may have its own building at the World's Fair to be held at Chicago in 1933 to celebrate a century of progress in ceramics. The desire is that the structure inside and out should be in agreement with the ideals of the ceramic industry. E.P.R.

Exhibits at the Leipzig Spring Sample Fair. R. C. BUSSER AND PAUL J. BEVERLY. *Commerce Repts.*, No. 24, p. 673 (1931).—The exhibits of porcelain, earthenware, and household glass were handled by 692 exhibitors. Special lines have been developed for the American market. Prices are down. Some of the exhibits are described. See also *Ceram. Abs.*, **10** [8], 611 (1931). E.J.V.

Convention of German standards for building. ANON. *Tonind.-Ztg.*, **55** [51], 741–42 (1931); for abstract see *Ceram. Abs.*, **10** [8], 611 (1931). W.M.C.

Gustav Tammann on his seventieth birthday, May 28, 1931. W. BILTZ. *Z. anorg.*

allgem. Chem., **198** [1], 1–31 (1931); *Naturwissenschaften*, **19** [22], 37 (1931).—A biographical sketch with portraits is given. L.T.B.

Pottery, the oldest industry. ANON. *Tonind.-Ztg.*, **55** [35], 510–11 (1931).—The oldest industry of men is supposed to be ceramics. Some tombs have revealed ceramic household ware used 17,000 years before the present time. W.M.C.

BOOKS AND BULLETINS

Patent Law for Chemists, Engineers, and Executives. F. H. RHODES. McGraw-Hill Book Co., New York. Price $2.50. *Mining & Met.*, **12** [295], 16 (1931).—The law of patents, the requirements for a patentable invention, the rights a U.S. patent confers, etc., are explained and illustrated by citations from court decisions. E.J.V.

Agenda Physique Industrielle. J. IZART. Dunod, Paris, 1931. *Mech. World*, **89** [2318], 540 (1931).—Data on units, temperatures, pressures, and densities are followed by a discussion of the transmission of heat, properties of gases, and drying of materials. The characteristics of pumps, compressed air, steam boilers and auxiliaries, refrigeration, and internal-combustion engine processes are also included. E.P.R.

Chemistry of Engineering Materials. ROBERT B. LEIGHOU. McGraw-Hill Book Co. 3rd revised ed., 684 pp. Illustrated. *Pit & Quarry*, **22** [6], 77 (1931).—The chemical properties of engineering materials from the viewpoint of the user are discussed. The book has 20 chapters including the following headings which are of special interest: water for steam generation, fuels, refractory materials for furnace linings, foundry sands, lime and gypsum products, Portland and other cements, clay and clay products, etc. E.P.R.

Materials Handbook. G. S. BRADY. McGraw-Hill Book Co., New York. 2nd ed. Price $5.00. *Mining & Met.*, **12** [295], 16 (1931).—This book contains information of the composition and properties of abrasives, brasses, bronzes, building materials, alloys, paints, chemicals, lubricants, etc., used in industry. E.J.V.

Mechanical Engineers Handbook. LIONEL S. MARKS. *Mech. World*, **89** [2317], 519 (1931); see also *Ceram. Abs.*, **10** [3], 236 (1931). E.P.R.

Corrosion of Power Plant Equipment by Flue Gases. H. F. JOHNSTONE. Univ. of Ill. Eng. Expt. Sta., *Bull.*, No. 228, 122 pp. (1931). Price 65¢. The bulletin describes the conditions which are prevalent in flue gases that cause corrosion and some of the steps that may be taken toward their elimination. The reactions taking place in boiler furnaces are discussed and their effect on corrosion and slag formation are pointed out. The results of tests made on various corrosion-resisting alloys and protective coatings under the conditions existing in flue gases are reported. A description is also given of new methods for the determination of the dew point and SO_3 and SO_3 concentrations in flue gases. Fundamental corrosion reactions are discussed. A.A.

Elementary Theory of the Internal Combustion Engine. F. W. LUDLAM. Blackie & Son, Ltd., London, 1931. *Elec. Rev.*, **108** [2790], 854 (1931); *Mech. World*, **89** [2318], 540 (1931).—The work is intended for students who are not well equipped mathematically. L. deduces the formula for the efficiency of the engine working on the Diesel cycle as

$$E = 1 - \frac{1}{2} \cdot \frac{\frac{1}{r_c^{n-1}} \left\{ \left(\frac{r_e}{r_s} \right)^n - 1 \right\}}{\frac{r_e}{r_s} - 1}$$

A careful investigation of the laws of gases and the principles underlying the conversion of heat into work and a chapter on the actual performance of internal combustion engines, the figures for which are taken from tests on commercial engines, are of distinct value. E.P.R.

PATENTS

Making vitrified argillaceous products. WILLIAM B. PINE, JOSEPH B. SHAW, AND MYRIL C. SHAW. U. S. 1,809,215, June 9, 1931. A process which comprises heating an argillaceous material selected from the herein-described group consisting of natural clays, shales, and mixtures thereof, to a temperature which, while below the P.C.E. value of the particular argillaceous material, is substantially above the temperature of incipient vitrification thereof, and applying molding pressure to the material while at the temperature to directly form a vitrified product.

Treatment of silica or compounds or combinations thereof, and the production of products therefrom. I. P. LLEWELLYN, T. J. I. CRAIG, A. KIRKHAM, AND P. SPENCE & SONS, LTD. Brit. 347,223, May 6, 1931.

Utilization of blast-furnace slags. P. P. BUDNIKOFF. Brit. 347,357, May 6, 1931.

Ceramic materials. W. W. TRIGGS. Brit. 347,486, May 6, 1931.

Manufacture of ceramic articles. J. F. JORDAN. Brit. 351,122, July 1, 1931.

Sintering clay. J. E. GREENAWALT. Brit. 351,690, July 8, 1931; for abstract see *Ceram. Abs.*, **10** [3], 212 (1931).

Book Review

Technical Methods of Chemical Analysis. Vol. III. Part I. Clays, Ceramic Products, and Refractories, Chemical Examination. H. V. THOMPSON. Gurney and Jackson, London, 1931. 2nd ed. 678 pp. Price £3 3s net. T. describes methods with which he has had practical experience and the text is not confused by continued reference to innumerable alternatives whose value is uncertain. The section might reasonably be enlarged in the future to include the examination of materials such as calcined bone and bone china from the pottery point of view. A chapter dealing with the examination of the various coloring oxides used in ceramics would also be useful. The section is full of useful detail and should prove valuable to those engaged in the industry. **Part II. Clays, Ceramic Products, and Refractories, Physical Examination.** S. R. HIND. H. has had a difficult task in dealing with physical tests, many of which are not entirely satisfactory and may be superseded in the near future. That this fact has been kept in mind is evident from the care which has been taken to discuss the theoretical principles underlying most of the important tests and to criticize the unsatisfactory features in each case. In addition, valuable references are given to methods used abroad which are different from those in use in this country at the present time. No doubt the necessity for economy in space has limited the scope but it is hoped that in future editions it may be possible to include a chapter on the thermal conductivity of refractories and the routine examination of the insulating properties of electrical porcelain. See also *Ceram. Abs.*, **10** [7], 528 (1931). (*Trans. Ceram. Soc.* [Eng.])

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Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIALS

SCOPE OF THIS SOCIETY'S ACTIVITIES

The members of this SOCIETY are primarily engaged in making better quality and lower cost ceramic products; in other words, a product that will find an increasing sales demand in a competitive market.

To this end, studies are made of the materials used, their geological and mineralogical history, their properties and the possible changes in their properties, their physical and chemical reactions when blended and heated, and especially their influence singly and together on the desired properties of the various fabricated ceramic ware.

Studies are made of the influence on the properties of ceramic products of different methods of conditioning and blending of the raw materials, and of the influence of fabricating methods.

Studies are made of the means to maintain constancy in product, both in quality and cost.

Studies are made of the economies and efficiencies of the various production operations.

There has been no questioning of the fact that all these things which

relate to production, including materials, methods, control, and supervision are well within the scope of the activities of this SOCIETY.

It is to a broader conception of the scope of this SOCIETY that attention must be given. Past-President Orton touched upon this in his presidential address[1] from which we quote.

> There is now urgent need of a reconsideration of our objectives. To the soldier or statesman, the attainment of one objective means the setting up of another. Nothing remains static in this world, nor in the great cosmos of which it is an infinitesimal speck. We must continue to grow and expand, or we shall inevitably shrink and die. Our early objectives have been so largely attained that there is a real and present danger that we may go stale if we do not address ourselves to a new task which will give outlet to our activities and put to a fresh test the initiative, driving force, and altruistic purpose which animated our early years.
>
> What should the new objective be? Opinions may well differ upon this. I will give you my own. I think the SOCIETY should now definitely set itself to serve (more directly) the ceramic industries on their business side. They think of us now as a group of technical men, who read papers to each other. They do not visualize in us a powerful and resourceful ally to bring in more business or to make their present business more profitable.
>
> What do the ceramic industries of the United States need? Most of all they need to develop unity of purpose, and ability to coöperate as a group for putting the ceramic industries boldly and broadly before the people. Other groups are doing this in their fields, especially our leading competitors, steel, cement, chemical products, and wood products. They have been able to sink their internal differences and unite in common programs to boost their work. Not so with us.
>
> The great groups of ceramic industries need aggressive leadership of national character to represent their products. They need representation in the places where standards are set and specifications are drawn. They need representation in government departments, where promotion plans are made and public questions are answered. They need sustained and intelligently developed publicity through which the people may be forced to learn the merits of what is produced, and the value of the services their products can render.
>
> What has the AMERICAN CERAMIC SOCIETY done to bring about this unity of purpose and coöperation in the ceramic industries? Very little in any specific direction. Our mere existence has been a useful influence, though passive in character and if these ideas are sound and practical and are generally recognized, why have we not stepped into the breach and made ourselves felt? Has it been lack of vision of the need and of our opportunity? In part, yes. But there are among us quite a few who have seen this picture and have lifted their voices like the prophets of old, calling aloud in the wilderness. Chief among these has been our able Secretary, Mr. Purdy, who never loses a chance to express this idea. But, as a body, we have not seen this picture or if we have seen it, we have done little about it.
>
> But, the one big obstacle which has held us back is not so much lack of vision, as it is lack of resources. And why do we lack resources? Because we have not yet convinced business executives that we are anything more than a body of technical men.
>
> We have made better technique possible. We have made research and its fruits available. Now, we must go further and show industry how to use research. We must translate research into new products and better products, and do our share by promotion to educate the public to accept and use them. When we can show plant managers and corporation heads that our work powerfully and directly aids in making new products and new markets, or even helps to hold their place against the aggressive inroads of competing industries, then they will not let us suffer for lack of resources.

The technical man who is not studying materials, processes, and product quality to obtain the largest and most profitable use of his company's facilities is not completely doing his job and is robbing himself of the most inspiring and creative motives.

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[1] *Bull. Amer. Ceram. Soc.*, **10** [4], 73–85 (1931).

Product development and product promotion are within the scope of the ceramic technologists and these are the most effective promptings to finding the materials and processes needed to meet the increasingly varied and exacting market requirements.

The technical man who has a clear vision of market demands will be the most effective in product development and control. This requires that he engage in product promotion and in studying the service demands which his products should be meeting.

The ceramic engineer and technologist, and in turn the SOCIETY through which he coöperates with his fellow ceramists, who is not working with the sales department as intimately as he does with the production department, is not securing for himself or for his employers the fullest possible returns from his services.

PRODUCTIVE SCHOLARSHIP

A scholar is a student. A scholarly man is one who uses that which he has learned. To say that one is scholarly implies that he has acquired information and can profitably use it.

To limit scholarship to tutored or classroom acquirements, or even to profound researches is pedantic. A scholar is one who has ability and judgment to make use of knowledge.

For an organized group to gage a person's productive scholarship by book learning or by a display of erudition in a written report of an investigation or observations is placing too much value on formal display of scholarship.

Who would say that Edison is not a scholar? Who would say that the many persons engaged in ceramics who, like Edison, have acquired and successfully applied information are not scholars? No organization can afford to accept such a pedantic definition of productive scholarship as to say that he who has not written formal reports of investigations is not a productive scholar.

This SOCIETY is a coöperation of scholars; those employed to make and report researches and those who are applying the results of researches.

The pledge used by our past Secretary and President, Edward Orton, Jr., when inducting officers of this SOCIETY appeals as a clear definition of productive scholars.

"The thing which marks one group of men as better than another is not their wealth, their culture, their skill. It is their spirit of coöperation, the ability and willingness to pool their energies unselfishly in the cause of human advancement."

This is a clean-cut recognition of the fact that civilization did not begin

until men coöperated and the advancement made was proportionate to the extent to which men coöperated.

In the organization of the Fellows of this SOCIETY[1], the Committee on Qualifications (Bleininger, Chairman, Tillotson, Secretary) presented the following interpretation of Article II, paragraph 5, of the SOCIETY's Constitution.

(1) He shall have held with unquestioned loyalty an active membership in the AMERICAN CERAMIC SOCIETY for at least five years.
(2) He shall be at least thirty years of age.
(3) He must possess high professional ideals and a good personal reputation.
(4) He must possess notable professional attainments as revealed in publications pertaining to Ceramic Arts and Science, by inventions, *or* by the responsible charge, for at least three years, of important ceramic work.

These articles of qualifications define the way in which the Fellows believe that a person shows productive scholarship. A lesser measure of what is meant by productive scholarship is pedantic and unworthy of a society built for coöperative purposes.

The AMERICAN CERAMIC SOCIETY is primarily industrial in character rather than academic. It is the success one attains in applying information and the whole-heartedness with which he supports coöperatively the organized means of fostering research and recording knowledge that distinguish the productive scholar in technical societies of this sort.

WHY THIS SOCIETY

Purely academic? No.

To publish papers? Only as a means to the essential purpose.

The fundamental objectives of this SOCIETY are "to advance the ceramic arts and sciences by meetings for the reading and discussing of papers, the publication of scientific literature, and other activities."

Any activity which will advance the ceramic arts and science is within the purview of this SOCIETY. Any conception of the SOCIETY's objectives short of this broad statement from the SOCIETY's Constitution is abortive, defeating, and certainly not tenable with any man who thinks.

All component parts of the SOCIETY must have this same broad conception of the SOCIETY's objectives. The Fellows of the SOCIETY cannot be selected wholly because of their academic accomplishments. The jurors who pass on the qualifications of those who are nominated to the Fellowship must gage the person's contributions to the advancement of the ceramic arts and science by this broad conception of the SOCIETY's objects.

Researches and research reports are essential to ceramic progress.

[1] *Bull. Amer. Ceram. Soc.*, **10** [2], 30–35 (1931).

These, however, are but as pilots pointing the way. Should the results of the researches not be applied in ceramic ware production and in ceramic ware use, the researches would be abortive and without value. We need these pilot researches. But could one be so shortsighted as to say that they are the most essential concern of a SOCIETY that has as its objective the advancement of the ceramic arts and science?

We hail the ceramic technologist who makes plant applications of science facts. He contributes even more largely to the advancement of ceramic arts and science than do those who work only in the laboratory, making and reporting researches. And especially should the greater honors be paid to those ceramic business executives who are so alert to the value of ceramic information proved and applied that they give unstintingly of their time and money, and of encouragement to their employees in support of this organized coöperative means for advancing the ceramic arts and science. These are the men who are contributing to constructive scholarship even more largely than are the abstract research laboratory workers.

There is a mutual dependency in this. The purely research worker is a vital factor but not more so than the plant technologist and the business executive who sustain the laboratories, point out the problems, and who determine the value of the laboratory findings.

PAPERS AND DISCUSSIONS

A SUGGESTED FACTORY PERFORMANCE INDEX[1]

By W. Keith McAfee

ABSTRACT

The growing complexity of product and manufacturing methods makes a rapid measuring stick of performance more necessary. A Performance Index is suggested that weights the various factors according to their respective effect on manufacturing costs.

The income statement and profit and loss analysis of our respective businesses are probably the most important reports we read. They usually come to us, however, on a monthly basis and arrive some time after the month is closed. They are interesting purely as a matter of history and to point out weak spots in our manufacturing or distributing organizations. One of the principal reasons for variation in profit in the ceramic industry is due to variation in factory performance. We are dealing with raw materials difficult to analyze in terms useful for technical control, and we believe that we are just beginning to evolve the fundamental technology necessary to this end. Consequently, it is also important to watch the day-by-day performance of our factories and this becomes more difficult as our factory processes and products become more complex.

Some years ago the company with which I am connected evolved a bonus system based upon the percentage of first quality ware produced. In order to take in as much of the factory operation as possible and make the bonus applicable to all the factory employees, the percentage of first quality ware was based upon the ware formed in the clay shop. The factory was producing sanitary pottery by the twice-fired process exclusively. All pieces of ware leaving the casting shop and not eventually showing up in the shipping department as first quality ware counted equally against this percentage. In other words, broken clayware, broken bisque ware, broken gloss ware, etc., were all charged off on an equal basis. Inasmuch as the value of each was different and consequently they were charged against costs at their proper respective values, the percentage of A ware calculated for the bonus was not a function of factory cost.

In the method used for calculating the bonus, a bogey was set at a definite percentage, for instance 90%. If the percentage calculated for the calendar month was less than 90% no bonus was paid. If it was higher than 90% (*i.e.*, 92%), the difference or 2% was used to calculate the bonus. Each foreman received 2% of his month's salary and each wage-earner received one-half of this or 1% of his month's wages. This automatically

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[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Management and Processes Session). Received March 5, 1931.

created a sliding scale. In general the more important workmen were paid higher wages and the percentage netted them, as a consequence, a larger bonus in dollars and cents.

It was realized from the start that the method of calculating the percentage was wrong. The company did not think, however, that performance would vary sufficiently to introduce any great errors. The falsity of this assumption was proved one month in which there was a very high loss in the gloss kiln, and a corresponding drop in loss in the bisque kiln and in percentage of off-grade ware. The company was obliged to pay a somewhat higher bonus than it had the month before, and when the books were closed it was discovered that the unit cost was considerably higher. The broken gloss ware had been charged into cost at the full cost of the finished ware, whereas the month before the corresponding bisque loss had been charged in at bisque cost and the off-grade ware had been reflected merely as a drop in net returns and showed only on the profit and loss sheet. Reduction in labor rates shortly afterward gave opportunity to discontinue this bonus.

While this bonus was in effect, the percentage of first-grade ware was plotted on curves on the factory bulletin board and the entire organization became accustomed to watching these curves every day as an index of the over-all factory performance. When the bonus was discontinued the index was really missed. This gave stimulus to developing a performance index that would be truly a function of manufacturing costs. The problem was further complicated by the factory partly changing over to the once-fired process. This later made the percentage of first quality ware out of the kilns no longer reliable as a measure of performance. A large proportion of the once-fired pieces at first had to be refired, but this did not add to manufacturing costs in the same way that the usual twice-fired refires did. The refiring operation was only the second trip through the kiln and, if the piece came out first quality, it exceeded the twice-fired piece in cost only by the extra glazing operation. It was, therefore, unfair to charge a once-fired refire against the percentage on the same basis as a broken piece of ware or as even a twice-fired refire. The management found itself entirely without any rapid measuring stick of factory performance.

A study of the flow sheet of this factory, as shown in Fig. 1, will disclose the salient factors involved. The slip preparation and casting are lumped into one factor because there is no leakage between these two operations, except some slip shrinkage and clay scrap return, which is already included in slip cost. The ware starting through the factory is proportional to the width, A, which is the flow leaving the casting shop. This flow immediately divides into twice-fired and once-fired ware. Some clayware is eliminated from each flow by the inspectors of green ware. This ware, known as "clay loss," is broken and returned to the slip house as indicated in

Fig. 1. The ware to be twice-fired goes directly to the kiln and comes out either as bisque ware or "bisque loss." The latter is thrown away and the former is delivered to the dipping room for stopping and glazing, from whence it proceeds to the kiln again for the second firing operation. It then comes out with the rest of the gloss ware.

The ware to be once-fired is delivered directly to the dipping room where it is glazed and delivered to the kiln. It emerges from the kiln as gloss ware. All of the gloss ware falls into one of four classifications, *viz.*, "regular selection" (first quality), "culls" (second quality), broken or "gloss loss" (which is thrown away), and "refires" (which are returned to the dipping room for reprocessing).

The ware the management is particularly interested in, and on which the performance should be based, is that classified as "regular selection." This is represented by the width, *B*, Fig. 1. The over-all performance would be calculated by dividing *B* by *A* and multiplying by one hundred to put the

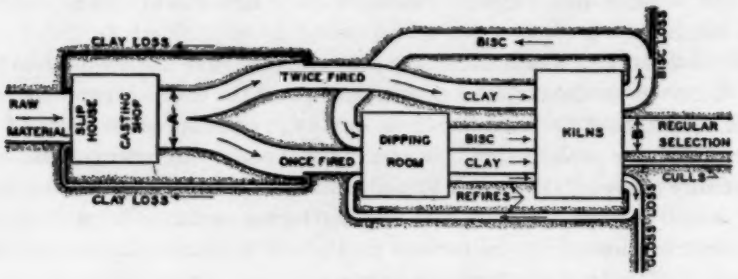

FIG. 1.

result in per cent. This is equal to charging off all the leakage between *A* and *B* at the same value. As pointed out before, this is not compatible with manufacturing costs. It is, therefore, necessary to weigh these leakages in proportion to their effect on the cost of the finished product.

There is a time element between the points *A* and *B* (Fig. 1) of from one to three or more weeks. The number of pieces passing through these points varies considerably from day to day, not only because of the various elements of factory operations causing variation, but also because of the difference in the relative size of the pieces of sanitary ware. Consequently the day-by-day variation between *A* and *B* may be very great and an index based on the division of one into the other would be misleading. A close approximation may be arrived at, however, by adding to *B* the sum of all the leakages for the particular day. This total is the "apparent processed" ware and will differ somewhat from the actual count leaving the casting shop.

Before the various leakages are added they must each be properly weighted according to their respective effects on costs. The extra amount

added to costs by each class of leakage is indicated in Table I. The amounts assumed are purely fictitious but are approximately correct for a tunnel kiln sanitary pottery. It is obvious that a broken twice-fired piece adds to costs the value of the standard cost of the piece. This is assumed to be $3.00 for a washdown unit (see column 14, Table I). A broken clay piece only adds to costs the labor and overhead expended on it up to the time of its loss, because the material is reclaimed and the reclaiming labor is included in "casting labor" (column 2, Table I). Thus the cost of losing a clay washdown unit is $1.00 or one-third as much as the loss of a gloss twice-fired washdown unit. The multiplier to be used for broken clayware or "clay loss" should therefore be 0.333. The other multipliers are calculated in the same way as will be apparent from a study of Table I.

Due to the large variation in size of sanitary ware, it is the practice in that industry to reduce everything to washdown units. The ware is converted into units taking the same kiln displacement as a staple washdown closet bowl. Thus a china lavatory taking the space of two washdowns is counted as two washdown units.

The actual number of washdown units in each class of defects, as well as the actual number of units classified as "regular

TABLE I.

Column No.	Class of Defect	1 Raw Material	2 Casting, etc., labor	3 One-fire glazing	4 First firing	5 Stop and glaze bisque	6 Second firing	7 Stop and glaze refire (1)	8 Third firing	9 Stop and glaze refire (2)	10 Fourth firing	11 Difference in value reg. selection—culls	12 Penalty for extra firing = 1.60–0.85	13 Credit for one-fire 0.75–1.00	14 Total cost of defect	15 Multiplier = $\frac{\text{Total}}{3.00}$
	Broken clay bisque	0.50	1.00		0.50										1.00	0.333
	" two-fire	0.50	1.00		0.50	0.50	0.50								2.00	0.667
	" refire	0.50	1.00	0.25	0.50			0.35	0.50						3.00	1.000
	" one-fire	0.50	1.00	0.25	0.50										3.10	1.033
	Refire two-fire	0.50	1.00	0.25	0.50			0.35	0.50	0.25	0.50				2.25	0.750
	" refire							0.35	0.50						0.85	0.283
	" one-fire							0.35							1.60	0.533
	Cull two-fire														0.35	0.147
	" refire											1.00			1.00	0.333
	" one-fire											1.00	0.75		1.75	0.583
												1.00		−0.75	0.25	0.083

TABLE II. FACTORY PERFORMANCE INDEX

Month of November, 1930

Date	Loss: Actual: Clay	Bisque	Two-fire	Refire	One-fire	Loss: Adjusted: Clay X − 0.333	Bisque X − 0.667	Two-fire X − 1.000	Refire X − 1.033	One-fire X − 0.750	Total loss	Refires: Actual: Two-fire	Refire	One-fire	Refires: Adjusted: Two-fire X − 0.283	Refire X − 0.533	One-fire X − 0.147	Total refires	Culls: Actual: Two-fire	Refire	One-fire	Culls: Adjusted: Two-fire X − 0.333	Refire X − 0.583	One-fire X − 0.083	Total culls	Total adjusted off-grade units
1	—	—	4.0	2.0	3.0	—	—	4.0	2.1	2.3	8.4	—	1.0	10.0	—	0.5	1.5	2.0	—	4.0	3.0	—	2.3	0.2	2.5	12.9
2	—	—	5.0	1.0	1.0	—	—	5.0	1.0	0.8	6.8	—	—	12.0	—	1.8	1.8	3.6	—	3.0	4.0	—	1.7	0.3	2.0	10.6
3	—	1.0	3.3	—	2.0	—	0.7	3.3	—	1.5	5.5	3.3	—	5.0	0.9	—	0.7	1.6	—	5.0	5.0	—	2.9	0.4	3.3	10.4
4	—	—	3.0	—	1.0	—	—	3.0	—	0.8	3.8	—	—	6.0	—	—	0.9	0.9	—	5.0	3.0	—	2.9	0.2	3.1	7.8
5	5.0	—	2.0	3.0	6.0	1.7	—	2.0	3.1	4.5	11.3	2.0	3.3	7.0	0.6	1.8	1.0	3.4	1.0	7.0	7.0	0.3	4.1	0.6	5.0	19.7

Date	Total apparent processed units: Daily	Cumulative total	Total regular selection units: Daily	Cumulative total	Performance index: Daily	Average to date
1	267.9	267.9	255.0	255.0	94.9	94.9
2	266.6	534.5	256.0	511.0	96.1	95.6
3	282.4	816.9	272.0	783.0	96.4	95.9
4	227.8	1044.7	220.0	1003.0	96.6	96.0
5	259.7	1304.4	240.0	1243.0	92.5	95.4

selection" are entered each day on a performance index sheet as shown in Table II. These data are obtained from daily production reports. Each class of defective ware is then multiplied by the proper multiplier as indicated in Table I, and as noted in the heading of Table II. The sum of these products is then entered in the proper column as "total off-grade units." Columns are provided for separate totals for each class of defect in order to bring out more clearly reasons for variation from standard performance. The sum of the total of "off-grade units" and "regular selection units" is then the "apparent processed units."

The daily performance index is calculated by dividing the "regular selection units" by the "apparent processed units" and multiplying by 100. A running total is kept of both "regular selection" and "apparent processed" and the total to date for the month of the former is divided by the latter to obtain the average performance index. This is, therefore,

the average performance to date for the current month. Both the daily and the monthly average performance indexes are plotted daily on the same curve sheet posted on the bulletin board. As a reference, the average for each month is also plotted for the current year on another curve sheet.

It may be pointed out that there can be no physical conception of this index, and it cannot be denied that there is difficulty in satisfying the factory executives on this point. There is, however, as much possibility of a physical conception of this performance index as in the case of any of the general business indexes published by various statistical organizations. We have all become used to watching these indexes even though few of us know exactly how they are calculated. Our own experience has been that drops in the daily performance curve indicate trouble and a glance at the performance index sheet shows where to look for the trouble without the necessity of going over all of the production reports for the day. When the trouble is located, reference can be made to the proper part of the detailed daily reports to learn the exact nature of it. It thus brings factory troubles to attention that might otherwise be overlooked by principal executives due to the fact that press of other duties makes it difficult to find time to follow detailed production records.

UNIVERSAL SANITARY MFG. CO.
NEW CASTLE, PA.

A TILE DESIGNED TO EFFECT A SCIENTIFICALLY BUILT WALL

BY A. W. KEICHLINE

ABSTRACT

Using the width of wall required for rigidity and the amount of clay necessary for compressive strength, a tile is shaped to meet construction details and economy in construction, and to lend itself to insulation, damp-proofing, reinforcing, and sound-proofing.

I. Introduction

It is a remarkable fact that the last one hundred years have witnessed more development in structural methods and materials than the combined thousands of years of man's civilization. As far as concerns the architect and the structural engineer there has been little change in clay building products with the possible exception of hollow tile units for both walls and floor construction. The great mass of clay building production used is still the lowly brick.

There has been some attempt to develop construction in metal, glass, and steel, and to prove the advantages of these materials, but there has usually been a return to the use of stone, brick, tile, wood, and similar mate-

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Cleveland, Ohio, February, 1931 (Structural Clay Products Division). Received January 1, 1931.

rials, for it has been found that design and durability are best expressed in the methods that have proved their advantages and their worth. It is only fair, however, to approach the subject of construction in a spirit of open-mindedness and with a desire to use the highest type of research work.

II. Requirements in Wall Construction

What then are the factors to be considered in a scientifically built wall and what materials would lend themselves best to the building of this wall?

Fundamentally, the material should afford the required strength; it should be durable and fireproof. It should lend itself to insulation, reinforcing, damp-proofing, and possibly sound-proofing. It should be readily adaptable to the plan and construction features of the building, and it should, in keeping with ideas of economy, show a saving. It should apply itself to the architectural treatment of the building.

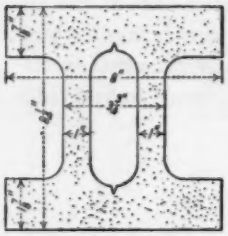

FIG. 1.

Inherent in fired clay in the form of tile or brick are found many of these properties. Designing a wall unit with the proper width for rigidity and using only the amount of clay required (with a factor of safety) in compression, it is to be shown whether or not this clay will meet the requirement specified. A design of tile shown in Fig. 1 is submitted for such an analysis.

In the development of steel, wood, and practically every material of construction, there has been a tendency toward improved design but still retaining an ample factor of safety. Common brick has been developed to carry 4000 or 5000 lb. per sq. in., but it has been computed that the lowest brick in a five-story apartment building carries 100 lb. per sq. in. In high steel buildings the steel carries the weight. Well within its required factor of safety a tile may be designed, with the required width for rigidity, to use one-half the clay now used.

The scientific principles used in industry have not been applied in the construction and functioning of buildings. In this respect builders and manufacturers lag far behind the development of the radio, airplane, and automobile.

III. Mechanical Features

A tile has been designed, therefore, to meet the requirements of a scientific wall. In analyzing these requirements it is obvious that an exterior and an interior face block are necessary and that the void should appear on the inside of the wall.

The interior surfaces of these face blocks may be painted with asphalt paint to eliminate infiltration, thus damp-proofing the wall. There are also no through mortar joints in the wall. It is not necessary to fur out the wall; plaster may be applied directly to the wall. This wall is an advantage over the present form of veneer wall, not only in fireproofing, but in eliminating the difference in expansion between the wood and the brick.

The size of the face blocks may be of standard brick size, or the tile may be made in larger sizes for use as a stucco base or as a backing for stone, and it would make an ideal foundation wall.

The face blocks are connected by a double web to meet a number of construction details. These webs are spaced to equal the width of a brick, making the unit easy to grasp and one unit forms the entire thickness of the wall. Given the wide assortment in color tones of brick and the different methods of laying them, the beautiful effects obtained by painting brick or with a stucco or stone veneer finish, many interesting surfaces may be developed.

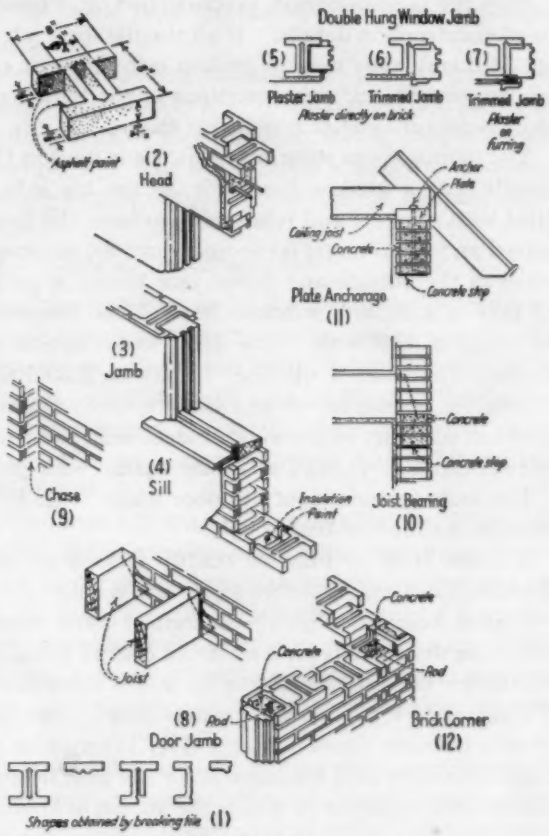

FIG. 2.

This tile is as easy to handle as brick and easier to handle than tile. One tile has the weight of a common brick and lays up the volume of two brick, and although more time is required to lay it than to lay one brick it can be laid in less time than is required to lay two brick. It will require less mortar than brickwork. It can be laid either side up and no time is lost in searching for special shapes as is required in some tile work. The tile may be broken to give a 2- by 4-inch face.

It would seem possible in the development of building units of this type to achieve greater stability of wall against buckling or splitting than is obtained by the usual brick wall laid in common bond.

IV. Construction Features

This tile is so designed, proportioned, and measured that it lends itself to all construction details. If all the tile for a job are kerfed (or a percentage of them), they may be broken into different shapes for use at window jambs, corners, and other portions of the building, making it unnecessary to manufacture and ship different shapes.

The figures given show how this tile is used in the different construction details. At a window head (Fig. 2) the tile is laid in header course and filled with concrete and reinforcing to form the lintel. No angle iron is required and so no metal is exposed. At the window jamb (Fig. 3) the space between the outside and inside face blocks is proportioned and measured to take a standard window box. This construction is made possible by using a half unit. The same construction would apply to a steel frame. The window sill (Fig. 4) may be placed as usual.

This tile is adapted to any interior trim: a plastered jamb with plaster direct on tile (Fig. 5), for wood or steel sash, a trimmed jamb with plaster direct on tile (Fig. 6), and a trimmed jamb with plaster on furring (Fig. 7).

The same features apply to door frame (Fig. 8) for head, jamb, and sill and also for interior trim.

A chase (Fig. 9) may be readily formed in the wall to accommodate plumbing, heating, or other pipes and wires.

A joist bearing (Fig. 10) is formed by a stretcher or header course. When the design calls for a stretcher course, a concrete stop is used and two courses are filled with concrete; in case of a rowlock or header course the tile is designed to form its own concrete stop. This construction also forms a firestop between floors. Plates (Fig. 11) may be anchored to the wall by using a concrete stop the same as for the joist bearing and filling the several courses with concrete in which the anchor is thoroughly embedded.

Corners (Fig. 12) may be made by using a half face block and filling the open area of the corner with concrete.

The bonding is secured in every unit. Any unusual ornamental bonding may be secured by the use of part tile as may be desired.

This tile meets practically all construction details and may be used whole or in part in connection with structural steel, reinforcing, insulation, dampproofing, and sound-proofing.

V. Weight and Cost

It requires less clay to make this tile than to make brick and because of its design it requires less time to fire. The tile requires less space in storage

and shipping than other tile or brick, and may be easily handled in bulk for loading, trucking, and in carrying to different parts of a building.

The tile would reduce the weight of the wall one-half. In the field of large buildings the reduction in weight per square foot of wall or floor is an urgent demand. It is probable that such a result would be accompanied by a material reduction in the cost per square foot of wall. It is certain that this construction would produce great savings in the supporting framework and foundations.

In residential and other small building construction, there is a need for reduction of cost per square foot of wall in place. Such reduction can come about only through the development of a building unit of proper design, even though the labor cost per unit may not be greatly affected. Such an accomplishment would amply compensate labor through the increase in the field thus opened up.

VI. Thermal Characteristics

The interior open area of the wall may be filled with insulating material, and when thus filled the wall has about three times the insulating value of a solid brick wall. In tornado and flood districts or where for any other reason reinforced walls are required, the wall may be filled at determined intervals with concrete and reinforcing. When it is desired to sound-proof, if the interior of the wall is filled with sound-proofing material it will aid materially in effecting this result.

Pioneer New Englanders took advantage of insulation by filling the hollow spaces in the walls of their cabins with grass and straw bound together with mud. Later, as other wall materials were developed and the heating plant came into use, insulation was lost sight of until a few years ago when it was commonly thought of as the safety covering on an electric wire. Now it is thought of as a means of keeping our rooms warm in winter and cool in summer. In this scientific age insulation should do far more than this.

Insulation should be a protection from the factors that are detrimental to our safety, health, and comfort, when used with available mechanical means for controlling the character of the air in buildings. The design of this tile is only a point toward better construction. It is not submitted as a final solution, but it is hoped that it will be constructive and quicken the imagination toward the ideal for which we should strive, for this is economic as well as a humanitarian problem.

VII. Summary of the Tests and Computations on New Type of Building Tile

(1) Crushing Strength Tests The unit submitted was subjected to a destructive loading in one of the standard testing machines. The tile failed when the gradually increased load reached

200,000 lb. Using this load and the actual tile dimensions the following data result:

	Sq. in.
Gross area (extreme length by extreme breadth)	60.06
Net total area	36.56
Load bearing area (net total area minus the area of 2 connecting webs)	29.06

DESTRUCTIVE LOAD

	Lb. per sq. in.
Gross area	3300
Net area	5470
Load-bearing area	6900

Tested to destruction and supported before failing a total load of 200,000 lb., which compares to a load of 5470 lb. per sq. in. of net area, or 6900 lb. per sq. in. of load-bearing area.

VIII. Computations of Conduction Characteristics

This tile had a total area of face of 18 sq. in., with a sectional area of the webs of 4 sq. in. The percentage of area, therefore, to be assumed solid was taken as $^4/_{18}$ or 22.2 and the percentage of air space equal to 77.8.

Assuming normal conductivity of brick to be 5 B.t.u. per sq. ft. per hour per °F temperature difference, the heat flow through the solid portion would be 0.132 B.t.u. per degree temperature difference face to face (conduction).

The heat flow through the hollow section was found by considering the unit as two simple walls separated by an air space, thickness of both walls and air space taken in conformity with the actual dimensions of the tile. This gives 0.52 B.t.u. per sq. ft. per degree temperature difference.

The sum of these two gives the total conduction per square foot per degree temperature difference, 0.13 + 0.52 or 0.65 B.t.u.

IX. Effect of Filling Space with Cork Dust

If the hollow space is filled with granulated cork, for which the conductivity is but 0.35, the resistance of the space is largely increased and the total conduction is reduced from the figure just given above of 0.65 B.t.u. to 0.200 B.t.u. per sq. ft. per degree temperature difference.

X. Transmittance of Heat from Air to Air

The above calculations give values for the conduction characteristics of the tile. If the overall values of the transmittance of heat from the air on one side of the wall to the air on the other side be desired, the film effect of both sides must be taken cognizance of. Doing this, the values without and with the insulating filling become as follows.

Hollow wall equals 0.392 B.t.u. sq. ft. per degree temperature difference.

Wall filled with cork dust equals 0.167 B.t.u. per sq. ft. per degree temperature difference.

BELLEFONTE, PA.

A NEW TYPE OF CERAMIC STRUCTURAL MATERIAL[1]

By W. E. Budge

ABSTRACT

A new type of structural material of low weight, made by mixing clay, bentonite, and lignite, is described. The lignite is burned out on firing and leaves a body made up largely of cells, walled with a hard, strong ceramic material. The effect of the ingredients, method of manufacture, and possible uses of this material are discussed.

I. Introduction

The process of mixing lignite with clays to produce a light-weight brick and tile which might be shipped long distances was used by Charles Weigel of the Hebron Brick Company ten years ago. The resulting products led him toward ceramic lumber which could be sawed and into which nails could be driven. This development required greater quantities of the lignite and also lignite of larger grain size. The ware was fired to temperatures below vitrification and, of course, did not develop its greatest possible strength.

To develop greater strength in both the dried and fired condition, the addition of various amounts of bentonite was tried. The bentonite was found to improve the plasticity of the mixture and its dried strength, and to make a stronger, harder ware when fired. The vitrification temperature was lowered and, upon vitrifying the ware, an interesting product was found to result.

Upon removing the outer skin of the ware on an abrasive wheel it was found to be made up of numerous angular cells connected together and walled with a glassy and hard shell of vitrified material. The walls were made harder than steel, had low absorption, and were gray in color. The ware has many interesting properties and should have a variety of uses.

II. Method of Manufacture

The mixture may be formed into ware with the ordinary machinery used in the present plants. It has been made on auger machines and also by pressing.

The ware may be dried quickly.

In firing, the ware must be stacked so as to expose all the faces but one for oxidation of the lignite. The temperature and kiln atmosphere must be controlled carefully until the lignite has burned out. The ware has been fired in muffles and in a downdraft rectangular kiln.

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[1] Presented at the Annual Meeting, American Ceramic Society, Cleveland, Ohio, February, 1931 (Structural Clay Products Division).

North Dakota contribution from the Division of Mines and Mining Experiments, University of North Dakota.

III. The Product

The ware made with this mixture is light in weight, being 0.3 to 0.5% as much as solid units. It is made up of about 60% of connected cells of a controlled size. When vitrified, the ware has a compressive strength of about 2000 pounds per square inch.

One of the most interesting properties of this material is that, when the outer skin is removed, it becomes a very good sound-absorbing material. In tests that were made on 2-inch tile, they were found to absorb 58 units at 512 cycles. The size of the pores may be varied during manufacture to absorb sounds of different pitches.

IV. Possible Types of Ware

(1) Brick Because of the lower weight, brick may be made in larger sizes than the present standard size and thus reduce the amount of mortar required and the cost of laying. Where the brick are to be exposed to the weather, a vitreous veneer of any desired color may be applied over the exposed faces during manufacture. Because of its cellular structure the material adheres well to mortar.

(2) Partition Blocks These may be made in large sizes and of the desired thickness. By dressing the material with abrasives before placing in the partition they can be laid with thin joints and can be used as the wall surface. This will require no further treatment of the surface. These tile may even be made with a solid membrane in the center to prevent the passage of air and sound.

(3) Hollow Tile Hollow tile of low weight may be produced which can be sawed and into which nails can be driven. The tile may be given a vitreous veneer of any desired color on the exposed surface, so that no surface treatment is necessary when the tile are exposed to the weather.

(4) Wall Tile Light-weight wall tile with a vitreous veneer of any desired color may be made. They have the advantage of low weight and good adherence to the mortar or cement.

(5) Acoustic Tile Tile for acoustic purposes may be made, with pores or openings of regulated size to fit them, for use under various conditions. Tile of this material will have the advantage of being fire-proof and water-proof as well as requiring no further surface treatment. They may be used in panels on walls and ceilings or as a covering of the whole surface.

UNIVERSITY OF NORTH DAKOTA
GRAND FORKS, N. D.

ACTIVITIES OF THE SOCIETY

TABLEWARE PROGRESS REPORT

Shape Construction Blue Prints

Square Shape

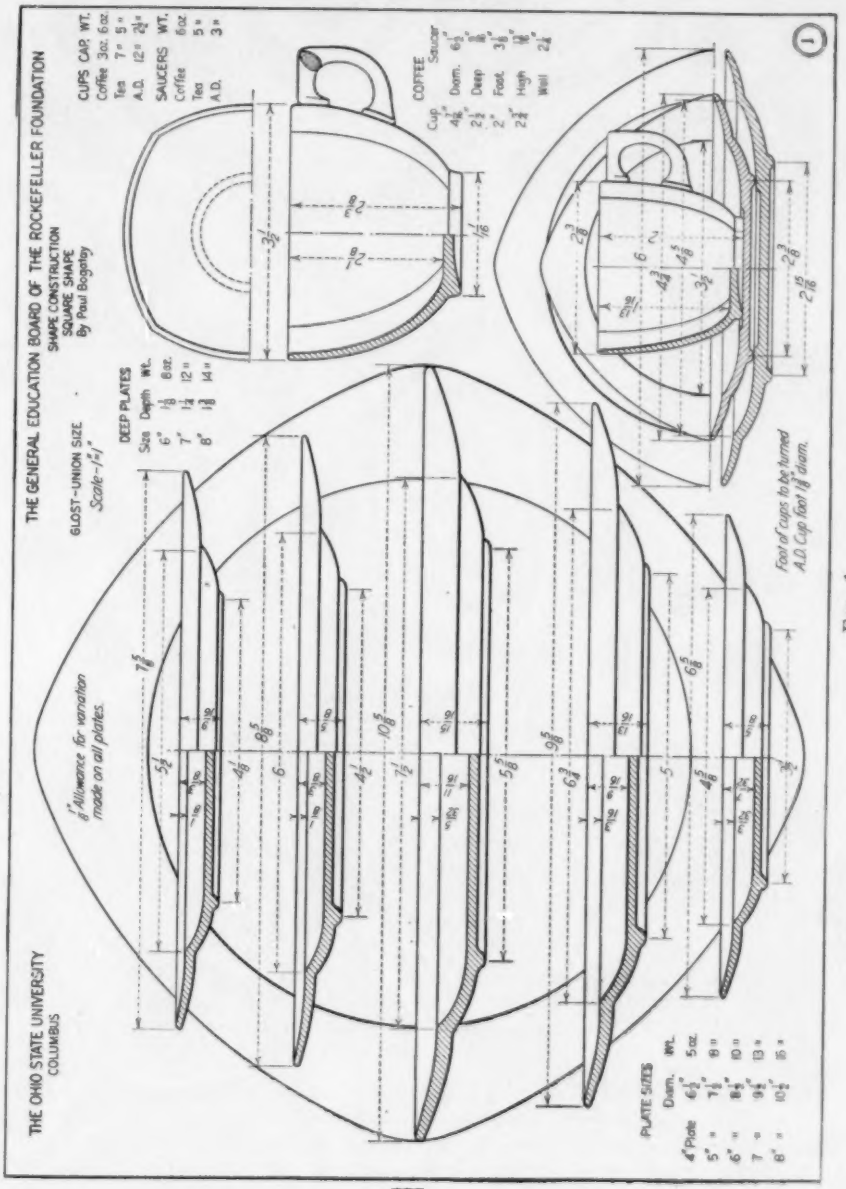

FIG. 1.

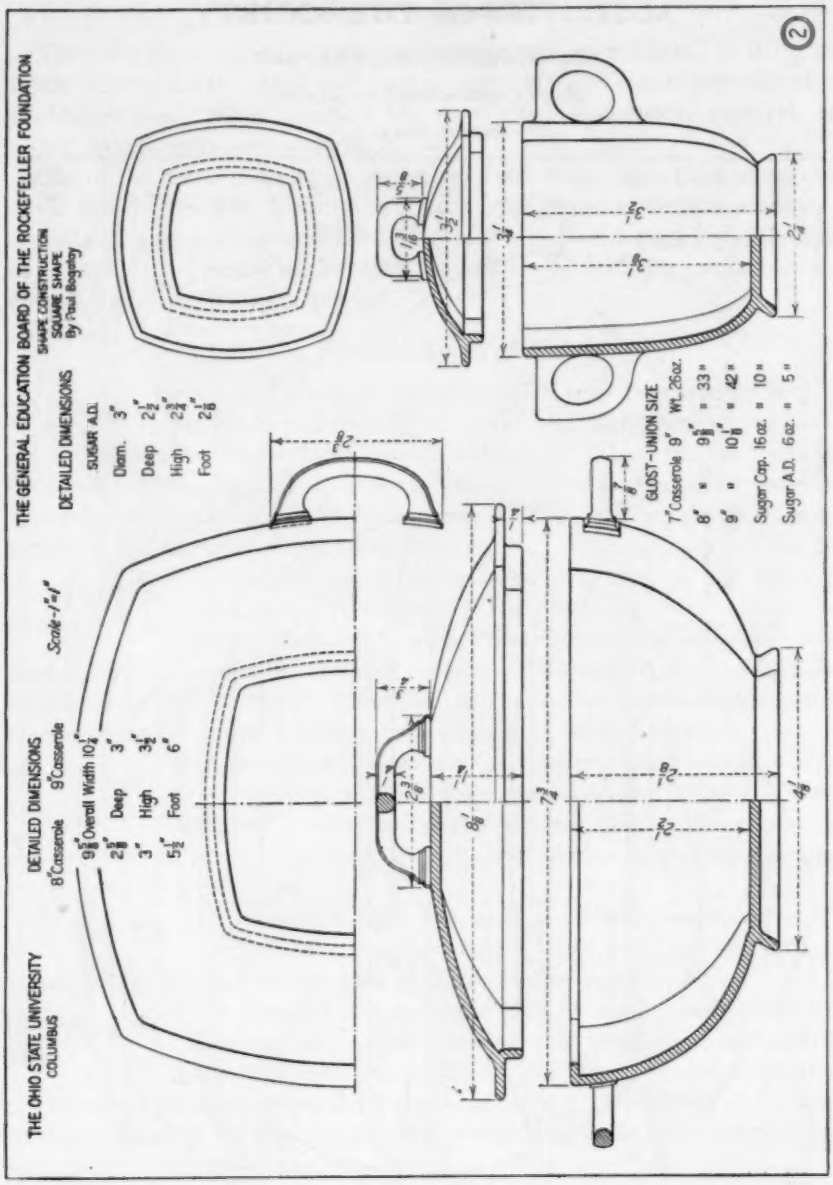

FIG. 2.

The General Education Board Research Fellowship at Ohio State University in Tableware Design submits the second series of blue prints dealing with shape construction. These working drawings cover the items of a dinnerware service in a simple square shape. These drawings, like the first series dealing with round shapes, are dimensioned

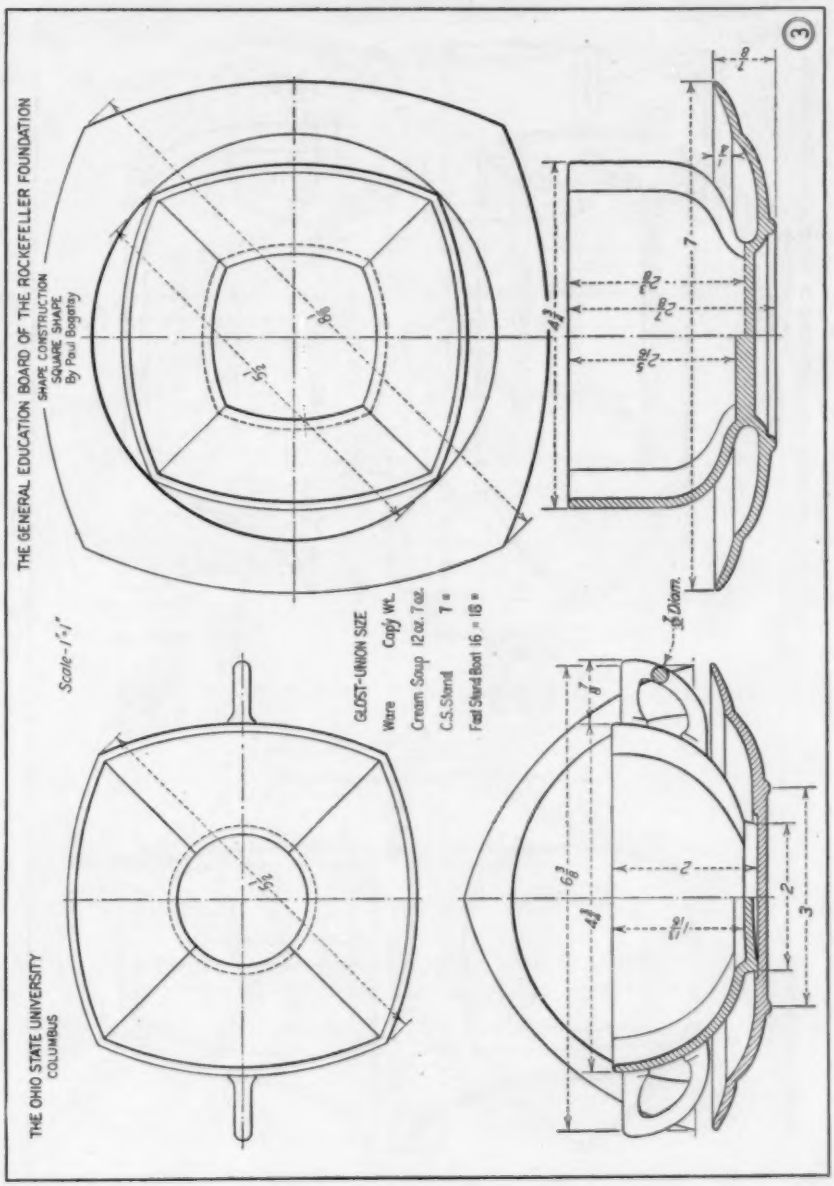

FIG. 3.

according to the specifications agreed upon by the U. S. Potters Assn. and the Brotherhood of Operative Potters.

The drawings present the square shape in its simplest terms. They should be useful as a fundamental basis upon which, with minimum effort, to build such modifications

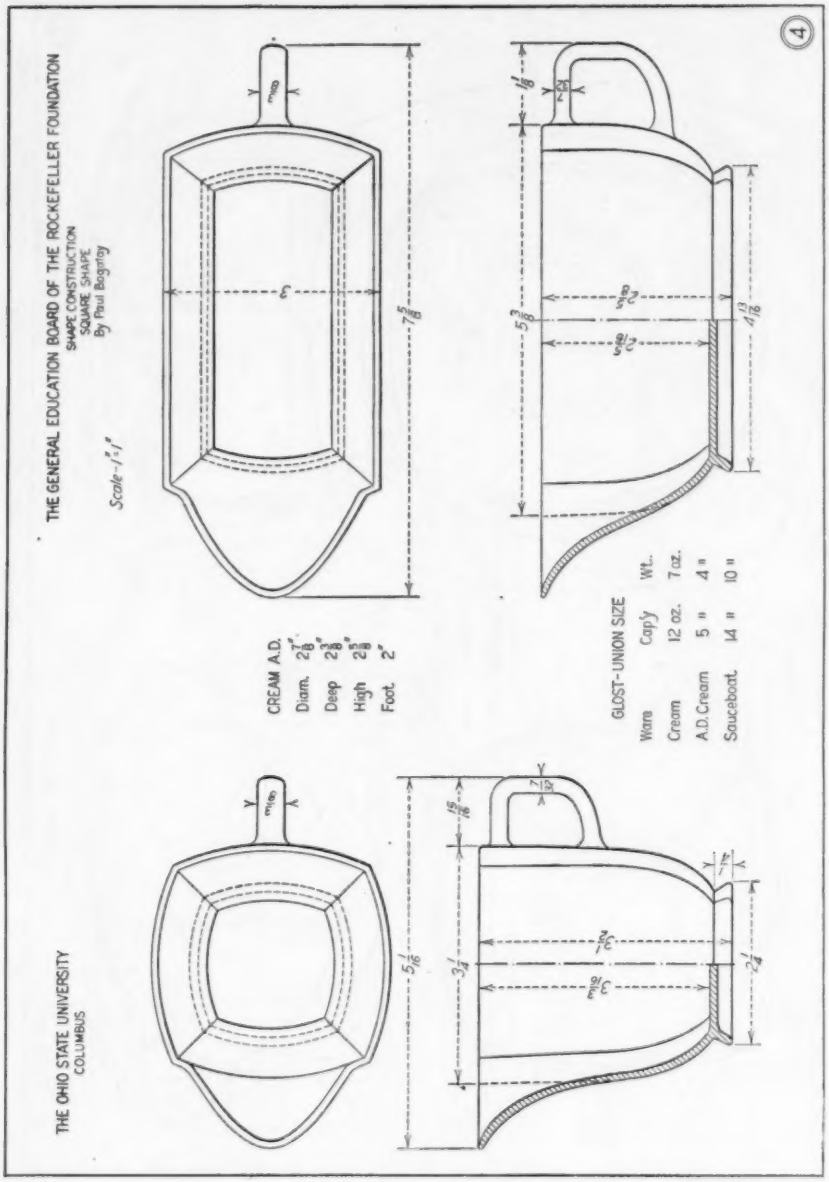

FIG. 4.

and minor ornamental details as are desired. By means of tracing over these drawings, the designer may retain the specified dimensions and proportions while adding at will such changes of detail as may suggest themselves.

These two series of constructional drawings present fundamental reference material

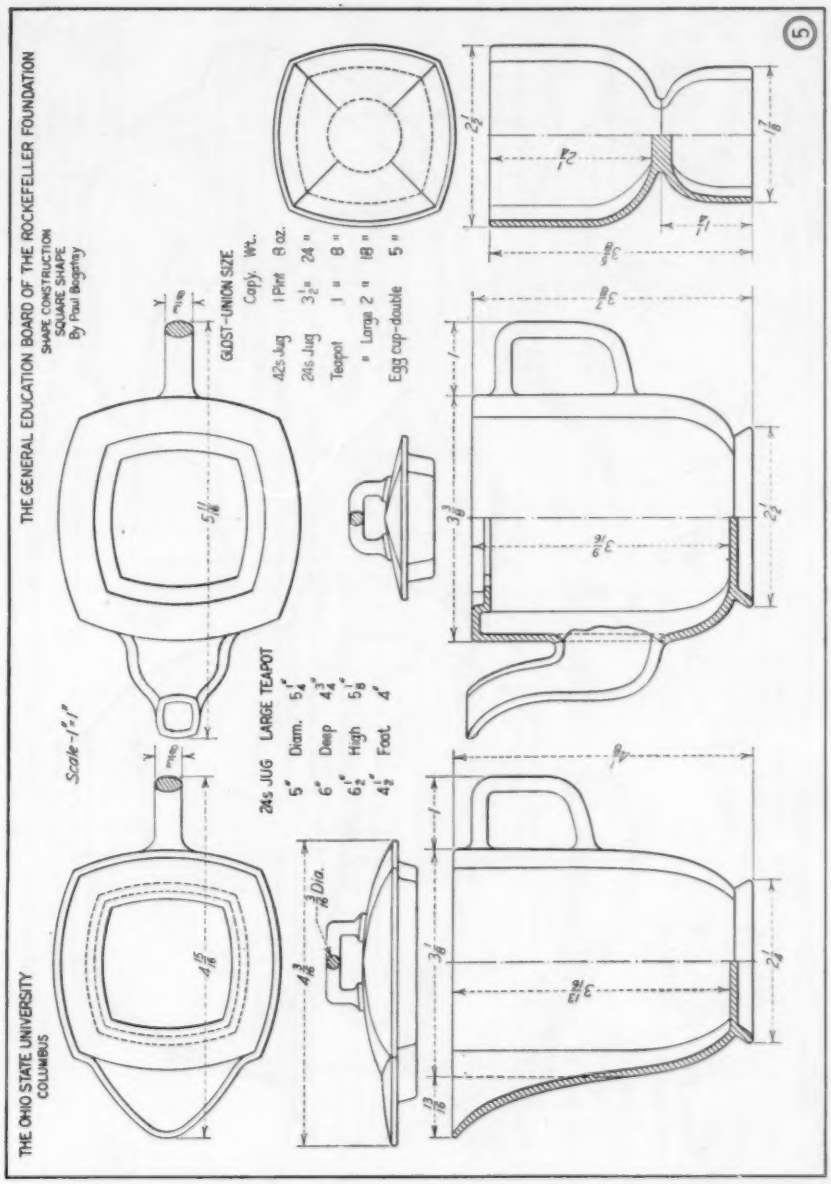

FIG. 5.

of permanent value to designers and executives in the tableware industry, both as a basis for discussion and detailed consideration of new shapes and as a direct aid to the designer in easily working out new shapes which conform to the specified standards.

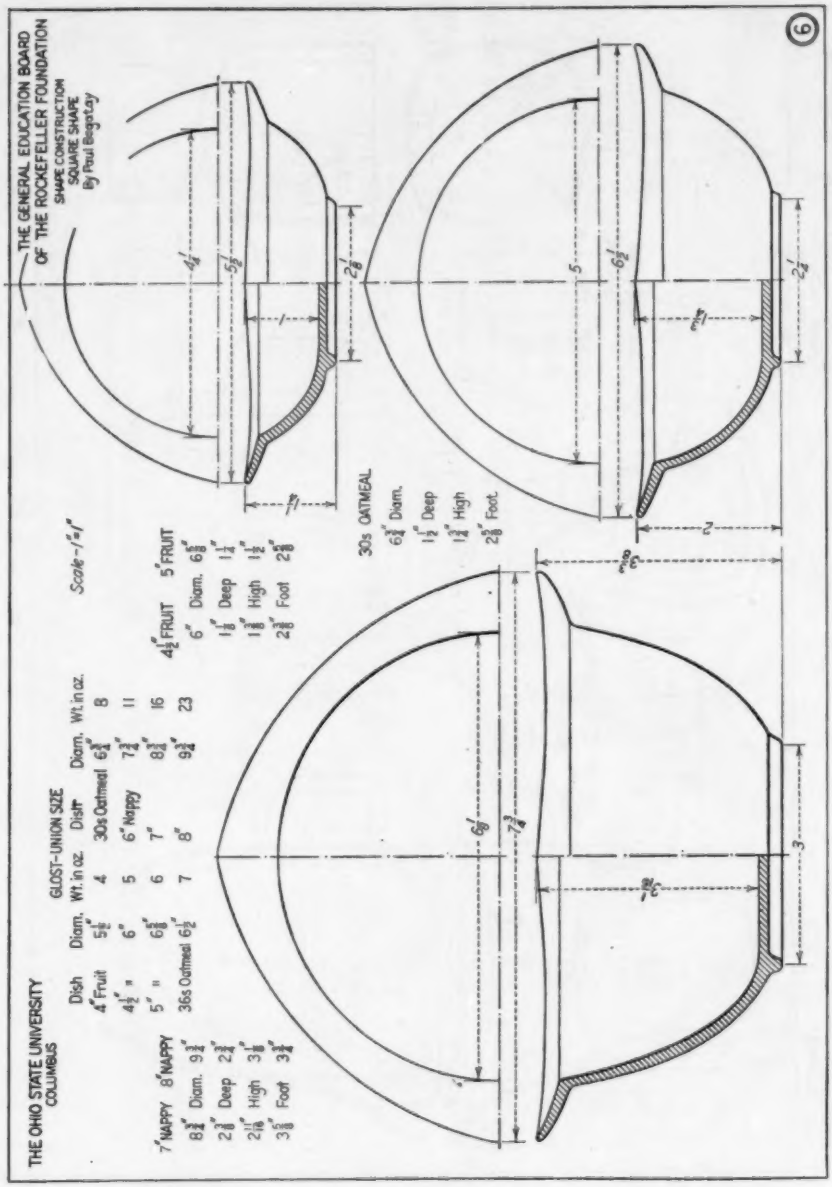

FIG. 6.

One copy of each series of blue prints has been sent gratis to each tableware manufacturer. Extra copies may be obtained at a price of five dollars per set (round or square) by applying to the Department of Fine Arts, Ohio State University, Columbus, Ohio. For round shape diagrams see *Bull. Amer. Ceram. Soc.*, **10** [7], 205–10 (1931).

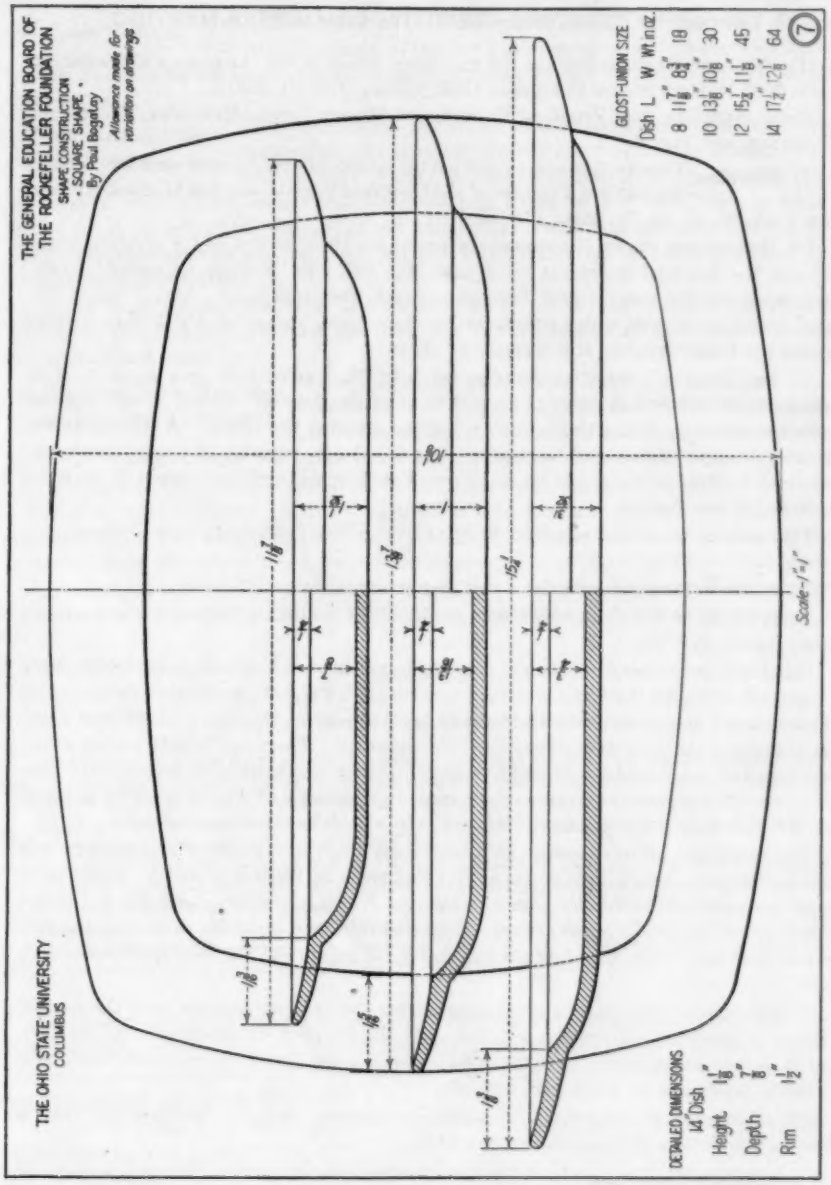

FIG. 7.

Comments and suggestions from manufacturers will be welcomed by those in charge of the study.

PAUL BOGATAY, *Tableware Research Fellow*
ARTHUR E. BAGGS, *Professor of Ceramic Art*

Issued July 25, 1931

REPORT OF TRUSTEES' EXECUTIVE COMMITTEE MEETING

(1) This meeting was held in the executive offices of the AMERICAN CERAMIC SOCIETY, 2525 N. High Street, Columbus, Ohio, Friday, July 24, 1931.

Those attending were President Eskesen and Messrs. Orton, McKinley, Kleymeyer, Henderson, and Purdy.

(2) Finances President Eskesen reported the results of a conference with Dr. William M. Buffum, Director of the Chemical Foundation, 654 Madison Avenue, New York, N. Y., on Tuesday, July 14.

Dr. Buffum was shown the annual statement for 1930, as well as for previous years, and also the financial statement as of June 30, 1931. Dr. Buffum requested a statement in which the general and *Journal* expenses were separated. Mr. Eskesen prepared such a statement, which statement has since been checked by Mr. Peters, verified against the ledger records, and corrections made.

At the Trustees' executive meeting on July 24, instructions were given to state separately the amount of money required to print the *Journal*, *Abstracts*, and *Bulletin* at the current size, during the next six months, including the Index. A statement was also requested of what would be required to print the manuscript of papers and books now in the office, which would be in excess of the normal current amount of material published in the *Journal*.

The amount of money required to print the *Journal*, *Abstracts*, and *Bulletin* of a normal size would be $11,278.

To print the excess manuscript would require an additional $13,046.

To print all of the manuscript now in the office, including the extra publications, would require $24,324.

Inasmuch as the current income, plus money in the bank, is just sufficient to carry the general expenses, it will be necessary to secure this $24,324, should the SOCIETY print all manuscript now in the office and balance the finances on December 31 without using any portion of the 1932 dues to pay the 1931 expenses. There are twenty papers which were listed on the Cleveland Meeting program, and on which we have had delivery date promised. These and the papers which come in midyear and for pre-meeting publication will take care of the January, February, and March issues of the *Journal*.

The possibility of canvassing the industry for a larger support of the SOCIETY was discussed at some length, and it was agreed that the only feasible procedure would be to make personal calls either by someone like the Secretary, who knows the industries as well as the SOCIETY's requirements, or by well-informed members in each of the geographic centers. This would be the means for taking care of our cash requirements in 1932.

It was pointed out that by continuing during the next six months with the normal amount of printing and general activities that the SOCIETY would break even in 1931, and that the accumulation of publications was in large part from previous years, and probably would not be duplicated in 1932.

Mr. Eskesen was empowered to arrange a meeting with Dr. Buffum, and such a meeting was arranged for Monday, August 3.

(3) Resolutions Endorsing Temple Act to Secure Appropriations for Topographic Maps Communication from the American Engineering Council regarding this SOCIETY joining with others in appropriate resolutions to the Director of the Bureau of Budget Chairman of the Appropriation Committee of the House was discussed, and it was moved by Mr. McKinley and seconded by Mr. Kleymeyer that General Orton be authorized to study the matter and to prepare such resolutions in the name of the Board as he would deem advisable.

(4) Color Council Mr. Eskesen reported the appointment and the acceptance of Walter P. Suter, Chairman of the Art Division, as delegated representative of this SOCIETY at the Inter-Society Color Council to be held in New York, N. Y., in September.

(5) American Refractories Institute Communications from the American Refractories Institute announcing its decision to withdraw from its merger with this SOCIETY were read, the withdrawal being effective December 31, 1931. This matter was discussed principally by Mr. McKinley, in which it was made plain that the purpose of the withdrawal of the American Refractories Institute from merger relations with this SOCIETY was not through lack of respect and appreciation of the SOCIETY.

It was moved by General Orton and seconded by Mr. McKinley that the communication from the American Refractories Institute be acknowledged with resolutions of acceptance of its decision.

(6) National Brick Manufacturers Research Foundation Mr. Kleymeyer announced that the executive committee of the N.B.M.A. had met in the Neil House on Thursday, July 23, and had completed all details for organizing the National Brick Manufacturers Research Foundation, and for closing up the affairs of the National Brick Manufacturers Association. Mr. Kleymeyer presented copy of the Constitution and By-Laws of the National Brick Manufacturers Research Foundation, also copy of articles of incorporation of the National Brick Manufacturers Research Foundation.

The articles referring to the affiliation with the AMERICAN CERAMIC SOCIETY were found in Article 3 of the By-Laws of the Research Foundation and read as follows:

Article III

Affiliation with the American Ceramic Society

Section 1: In order to promote the closest coöperation between the Foundation and the AMERICAN CERAMIC SOCIETY, all members of the Foundation, except Technical Members, shall be tendered to the AMERICAN CERAMIC SOCIETY for membership.

Section 2: All reports and bulletins of the Foundation shall be printed by the AMERICAN CERAMIC SOCIETY without cost to the Foundation.

Section 3: The Foundation will pay to the AMERICAN CERAMIC SOCIETY the sum of twelve and one-half dollars ($12.50) per year for each member, except Technical Members, of the Foundation to whom the SOCIETY shall issue certificates of membership.

Section 4: Reports of all Technical Committees shall be available to the Program Committee of the Structural Clay Products Division of the AMERICAN CERAMIC SOCIETY for presentation at the meetings of the Division.

It was announced that Secretary Douglas F. Stevens of the Foundation and Secretary Purdy were to arrange for a meeting in Danville for the purpose of turning over records, preparing announcements, and proceeding with the collection of dues in the interest of the Foundation and of the SOCIETY.

At the meeting of the Foundation on July 23, Secretary Purdy offered, in the name of the Trustees, to be custodian of the N.B.M.A. emblems, and such other things that have a historical value. Mr. Kleymeyer reported to the executive committee of this SOCIETY on July 24 that this offer had been accepted by the executive committee of the N.B.M.A., and that Mr. Stevens was preparing to ship them to the executive offices of the SOCIETY, there to be suitably displayed and preserved.

The executive committee unanimously accepted the custodianship of the N.B.M.A. emblems and authorized assurance to the retiring executive committee of the N.B.M.A. that they would be properly cared for.

(7) Printing Contract Communication from the Mack Printing Company dated July 6, copy of which has been sent to the Board and the Publications Committee, was read. Quotations submitted by McGee Brothers of Piqua, the Waverly Press, Baltimore, and Kable Brothers of Mt. Morris were also shown.

Statement was made of the progress in negotiations with the Evangelical Printing Company of Cleveland. Mr. McKinley told of the facilities and of the work of the Evangelical Press, and of the fact that they were doing all of the printing for the American Society for Steel Treating, and that they appeared to be capable of handling the printing of the SOCIETY.

As soon as the Evangelical Press has submitted its bids, they will be presented to the Board and to the Committee on Publications.

(8) Registration Fee at Annual Meeting This was discussed and an informal expression given that because of the registration fee of $2.00 to be charged at the Washington Meeting, delegates should be admitted without charge to the dance.

(9) Annual Banquet The question of an annual banquet was brought up and it was recommended, without formal motion, that the Local Committee and the Division officers try to work out a scheme whereby the Division dinners would be given in a single room, to be followed by such business as each should desire, or such general social affair as the Local Committee will arrange.

(10) Invited Guests at Annual Meeting It was moved by General Orton, seconded by Mr. Kleymeyer, that the Secretary be empowered to work up a list of distinguished guests to whom invitations should be sent, inviting them to attend the Meeting without payment of the registration fee.

(11) Glass Division Summer Meeting The program for the Glass Division Summer Meeting was read. The Glass Division will leave Baltimore by boat on September 11, arriving at Old Point Comfort on September 12, and will return by boat on September 13.

It was moved by General Orton and seconded by Mr. McKinley that Miss Emily C. Van Schoick should attend this meeting of the Glass Division with the Secretary of the SOCIETY and Mrs. Lois Purdy Turner, who is Secretary of the Glass Division.

(12) Century of Progress The status of these plans was reported by the Secretary. A meeting was held in Chicago on July 23, report of which was not at hand for the Trustees' executive meeting on July 24. It has since been learned that the committee which met in Chicago on the 23rd was divided on the question of attempting to secure from the ceramic industries a sufficient sum to finance the surrounding of the portion of the general exhibits hall assigned to ceramics with ceramic material. Led by the face brick interests this proposition is to be pushed to a conclusion satisfactory to all parties interested, but Mr. J. L. Murphy reports that it seems certain that there will be no attempt to have any outside portion of the general exhibit hall built with ceramic materials.

The question then came up on the financing of the general Century of Progress ceramic exhibit for which a space 18 by 60 feet square has been allotted by the Chicago Fair. Mr. Murphy reports that this proposition and also the assistance to the Fair in securing sale of the 100 booths in the ceramic section of the exhibit hall will have to be under the auspices of the AMERICAN CERAMIC SOCIETY. Mr. Murphy is willing to continue to serve as general chairman of this project, and he has asked for recommendations of suitable personnel for the several committees which will be necessary to carry out the Century of Progress exhibit in ceramics and also the ceramic portion of the science exhibit and the ceramic participation in the books which are to be compiled and issued under joint auspices of the Chicago Fair management and the industries.

The question of an International Ceramic Congress to be held in Chicago during the summer of 1933 has not yet been considered, but should be taken up at once.

It is recommended that this Century of Progress project be made a matter of immediate and earnest consideration.

(13) Certificate of Honorary Membership It was moved by Mr. Kleymeyer and seconded by Mr. McKinley that General Orton and the Secretary be empowered to prepare suitable certificates of Honorary Memberships for Dr. Mellor, Dr. Schott, Dr. Day, and for the others who are Honorary Members of the SOCIETY.

(14) A.S.T.M. Committee on Fuel Oils A communication from Harry F. Tapp, Secretary, American Oil Burner Association, 342 Madison Avenue, New York City, requesting the SOCIETY to appoint a representative on the Committee on Fuel Oil Specifications was considered. The Secretary was asked to determine who should be delegated as representative of the SOCIETY.

(15) Revolving Fund Criticisms of Messrs. Silverman and Henderson were considered. The method and purposes of the revolving fund were studied. It was demonstrated that the revolving fund credits and debits were handled in a businesslike way, much as would be petty cash of a business organization, with the exception that in this SOCIETY the Assistant Secretary uses checks on the Northern Savings Bank. The Secretary will work out a scheme for paying out fewer items from the revolving fund and withholding as many as possible of the midmonth payments for the monthly issuance of vouchers on the SOCIETY's principal bank deposit, which at present is with the First Citizens Trust Company.

NEW MEMBERS RECEIVED IN JULY

PERSONAL

Charles Owen Fairchild, C. J. Tagliabue Mfg. Co., 540 Park Ave., Brooklyn, N. Y.
Nicholas Planz, A. O. Smith Corp., Milwaukee, Wis.
Frederick Wegmann, A. O. Smith Corp., Milwaukee, Wis.

Membership Workers' Record

PERSONAL

H. G. Thomson 2	Office 1	Total 3

ROSTER CHANGES IN JULY

CORPORATION*

General Ceramics Co., Lewis Albrecht (voter), 71 W. 35th St., New York, N. Y. (225 Broadway.)
Northwestern Terra Cotta Co., B. Purcell (voter), 4417 Oleatha Ave., St. Louis, Mo. (5739 Manchester.)
Plibrico Jointless Firebrick Co., W. A. Schaefer (voter), 1800 Kingsbury Block, Chicago, Ill. (1130 Clay St.)

PERSONAL*

Baker, Donald R., Metropolitan Paving Brick Co., Canton, Ohio. (35 E. Lane Ave. Columbus, Ohio.)

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* Addresses within the parentheses ( ) represent the old addresses.

These roster changes which are published each month may be checked against the complete Membership Roster which appeared in the July, 1929, issue of the *Bulletin*. Copies of this issue may be obtained from the Secretary's office, price $2.00.

Bassett, Leon B., Alfred, N. Y. (Milton, Wis.)
Borland, H. R., R. R. No. 8, Peoria, Ill. (1208 Oak St., Danville, Ill.)
Dietrich, W. F., 782 40th Ave., San Francisco, Calif. (683 Alvarado Row, Stanford University, Calif.)
Fitzpatrick, John, 139 79th St., Niagara Falls, N. Y.; Carborundum Co. (572 Terrace Ave., Clifton, Cincinnati, Ohio.)
Gallup, John, Box 33, Rutgers University, New Brunswick, N. J. (Alfred, N. Y.)
Given, Conrad W., Michigan Steel Corp., Ecorse, Mich. (Ferro Enamel Corp., Cleveland, Ohio.)
Gotham, Thomas B., Whiting & Mead, Los Angeles, Calif. (Darm's Hotel, Burbank, Calif.)
Greaves-Walker, A. M., Libbey-Owens-Ford Glass Co., Toledo, Ohio. (317 W. 10th Ave., Columbus, Ohio.)
Hayes, Walter, Davidson Enamel Co., Connersville, Ind. (1989 Iuka Ave., Columbus, Ohio.)
Holscher, H. H., 1821 South 13th St., Maywood, Ill. (Bureau of Standards, Lord Hall, O. S. U., Columbus, Ohio.)
Kauffman, John R., Dept. of Ceramics, Rutgers University, New Brunswick, N. J. (211 East Pearl St., Miamisburg, Ohio.)
Lees, Arch A., 411 Avon Drive, Mt. Lebanon, Pittsburgh, Pa. (1110 Franklin Ave., Wilkinsburg, Pa.)
Little, James S., Georgetown Porcelain Co., Georgetown, Ontario, Canada. (126 St. George St., Toronto, Canada.)
Lynn, Don C., Smithton, Pa. (Mellon Institute, Pittsburgh, Pa.)
McNerney, Edward A., Hanley Co., Lewis Run, Pa. (624 S. Main St., DuBois, Pa.)
Moncrieff, James W., P. O. Box 327, Newell, W. Va. (Box 93, East Liverpool, Ohio.)
Navratiel, Hans, Fritschestr. 41 I, Berlin-Charlottenburg, Germany. (Paralell Str., 6, Beuthen Oberschlesien, Germany.)
Page, George A., Stockton Fire Brick Co., Pittsburgh, Calif. (University of Washington, Seattle, Wash.)
Peters, Bernard C., 152 Columbia Ave., Seward, Neb.; Seward Brick Co. (Danbury, Iowa.)
Powell, C. G., P. O. Box 246, La Junta, Colorado. (512 Maurry St., Alcoa, Tenn.)
Schaefer, Earl F., 342 Berkley Road, Indianapolis, Ind. (1224 Clawson St., Alton, Ill.)
Schwartzwalder, Karl, A C Spark Plug Co., Flint, Mich. (912 Oakwood Ave., Columbus, Ohio.)
Shands, Everett H., Porcelain Enamel & Mfg. Co., Baltimore, Md. (Box 5626 College Sta., Raleigh, N. C.)
Slaven, S. J., Mullite Refractories Co., Seymour, Conn. (590 Rogers Ave., Brooklyn, N. Y.)
Thiemecke, Harry W., Westinghouse Electric & Mfg. Co., Derry, Pa. (116 W. Norwich Ave., Columbus, Ohio.)
Wilcox, Howard G., Box 330, Willamina, Oregon. (College of Mines, University of Washington, Seattle, Wash.)

NECROLOGY

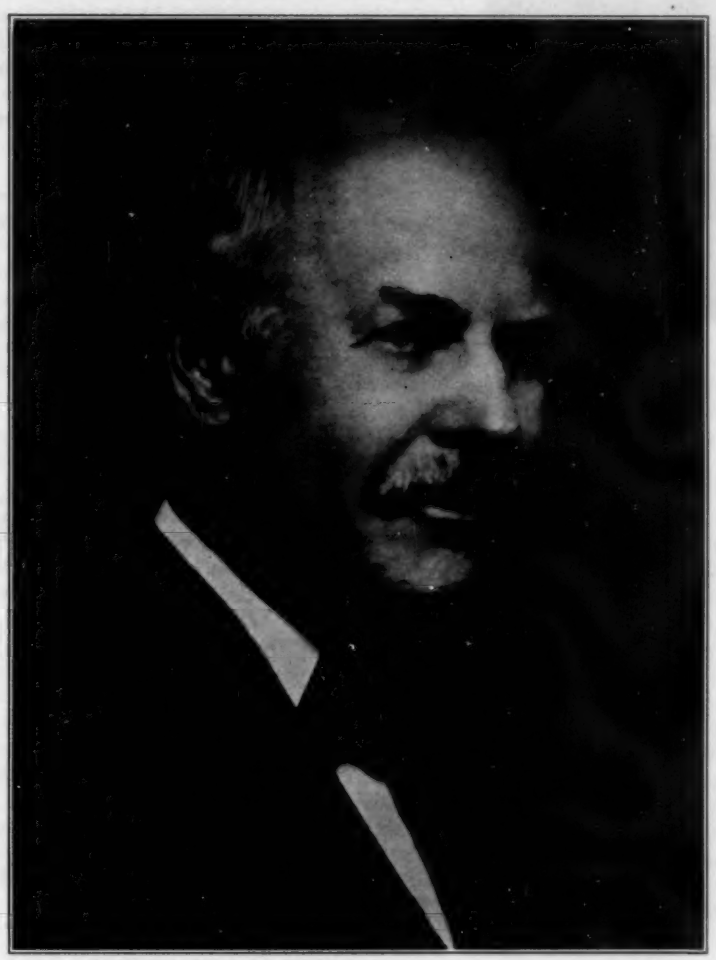
Edward G. Acheson

The death of Edward Goodrich Acheson occurred in New York on July 6, 1931, after a short illness. Dr. Acheson was born at Washington, Pa., March 9, 1856. He attended school at North Sewickley, Pa., for a year and later went to a school at Bellefonte, Pa.

In 1880, Dr. Acheson went to work for Thomas Edison and in 1881 he went to Europe to exhibit Edison's inventions at the International Electrical Exposition in Paris. After the exposition he built lamp factories and installed Europe's first artificial lighting plants in France, Italy, Belgium, Holland, and other countries.

In 1891, Dr. Acheson discovered carborundum and formed the Carborundum Company.

Dr. Acheson was charter member and past president of the American Electro-Chemical Society, charter member and vice-president of the American Institute of Chemical Engineers, fellow of the American Assn. for the Advancement of Science, member of the American Institute of Electrical Engineers, the American Chemical



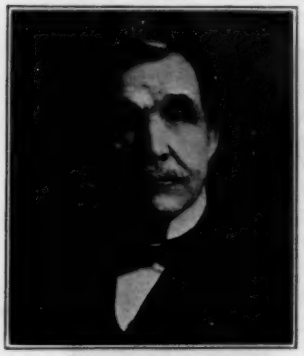
EDWARD GOODRICH ACHESON

Society, and the Franklin Institute. He had been a member of the AMERICAN CERAMIC SOCIETY since 1920.

While Dr. Acheson's fame as a scientist is well known among abrasive engineers he will always be remembered as the discoverer of silicon carbide, the man who actually discovered a new cutting agent, the value of which is impossible to estimate in industrial lines.

Edward Hart[1]

Dr. Edward Hart died at Easton, Pa., on June 6, 1931. He was born in 1854 and educated in Doylestown, Pa.



EDWARD HART

After studying law for two years he became a pupil of T. M. Drown in Philadelphia, and went with him to Lafayette College as assistant. The following year, upon Dr. Drown's resignation, he became Professor of Chemistry, Dean of the Scientific Department, and finally, in 1924, Emeritus Professor. In the meantime he had been a Fellow and Ph.D. of Johns Hopkins University and LL.D. of Lafayette.

He was editor of the *Journal of the American Chemical Society* for nine years and of the *Journal of Analytical Chemistry* for seven years.

Dr. Hart had been an active member of the AMERICAN CERAMIC SOCIETY for many years and undertook on his own responsibility the printing for the SOCIETY of the Collected Writings of Herman Seger.

SUMMER MEETING OF THE GLASS DIVISION

Old Point Comfort, Va., September 11–14, 1931

A general invitation to all the members of the AMERICAN CERAMIC SOCIETY has been issued by the Glass Division to attend its annual summer meeting at Old Point Comfort, Va., on September 11 to 14, 1931. Technical meetings of the Glass Division will be held, but these will not interfere with a restful vacation trip for those who wish to attend these sessions. An exhilarating trip on the boat from Baltimore to Old Point Comfort, with golf and bathing as attractions in Virginia are promised and the Glass Division hosts urge as many members of other Divisions as possible to take advantage of this opportunity to become acquainted.

The Glass Division members and their guests will leave Baltimore by the Old Bay Line Boat, Friday, September 11, at 6:30 P.M. (Pier 10, Light Street). Saturday and Sunday will be spent at Old Point Comfort and the return trip will be made Sunday evening, arriving in Baltimore, Monday, September 14, at 7:30 A.M.

The total cost of transportation, stateroom, meals, and hotel accommodations will amount to $18.95 per person. If members have not received a card on which to make reservations for this trip, they are asked to notify Mr. L. C. Roche, Maryland Glass Corporation, Baltimore, Md.

CONSTITUTION OF THE NATIONAL BRICK MANUFACTURERS RESEARCH FOUNDATION

Article I

Name

This Corporation shall be known as the National Brick Manufacturers Research Foundation.

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[1] Reprinted from *Chem. & Ind.*, **50** [29], 623 (1931).
See also *Bull. Amer. Ceram. Soc.*, **3** [10], 405–406 (1924).

Article II

Purpose

This Foundation shall be organized as a Corporation not for profit, with the following purposes:

(1) To initiate, foster, conduct, and direct research in the fields of, and to collect, codify, distribute, and promulgate data pertaining to the manufacture, production, properties, and uses of structural clay products.

(2) To secure the necessary funds, equipment, and services to accomplish the foregoing objects.

(3) To secure, hold, and disburse endowments to assure the continuity of its operations and perpetuate its objects, and all things incidental to the foregoing.

Article III

Membership

The membership of this Foundation shall consist of all persons and Corporations who contribute funds or services to the carrying out of its objects, as provided for in the By-Laws.

Article IV

Administration

Section 1 Trustees The affairs of the Foundation shall be managed by a Board of Trustees consisting of nine members. In the first Board of Trustees the term of office of three shall be for one year, of three others for two years, and of the remaining three for three years. The Board shall be perpetuated thereafter by the election of three members each year for terms of three years.

Section 2 Officers The officers of the Foundation shall be a President, a Vice-President and a Secretary-Treasurer who shall be elected by the Trustees, from their own number at the first meeting of the Board following the annual meeting of the Foundation, for a term of one year or until their successors shall have been elected and qualified.

Section 3 Meeting of Board The Board of Trustees shall meet as soon as possible after the annual meeting of the Foundation and have at least one other meeting during the year. Other meetings may be held at their discretion.

Section 4 Quorum A majority of the Board shall constitute a quorum.

Section 5 By-Laws The Board of Trustees shall be governed by such By-Laws as may be adopted by the Foundation.

Article V Research The Research Work of the Foundation shall be carried on by Technical Committees authorized by the Board of Trustees. The majority of the membership of all such Committees shall represent the technical and consuming interests.

Article VI

Meetings

Section 1 Annual Meeting The annual meeting of the Foundation shall be held at the time and place of the Annual Meeting of the AMERICAN CERAMIC SOCIETY.

Section 2 Special Meetings Special meetings shall be called by the President at any time or place when authorized either by vote of the Board of Trustees or by petition of 10% of the membership, but not less than twenty-five members.

Section 3 Quorum Twenty-five members shall constitute a quorum at any meeting of the Foundation.

Article VII

Amendments

This Constitution may be amended only in the following manner: An amendment must be endorsed by the Board of Trustees or by twenty-five members and submitted to the President who shall send copies of the proposed amendment to all members of the Foundation at least thirty days before the annual or special meeting at which the amendment is to be voted upon.

For adoption, the proposed amendment must receive the favorable vote of at least two-thirds of the members present at said meeting.

BY-LAWS OF THE NATIONAL BRICK MANUFACTURERS RESEARCH FOUNDATION

Article I

Membership and Contributions

Section 1 There shall be the following classes of Membership:

(*A*) *Individual:* Individuals who shall make a minimum annual contribution of twenty-five dollars ($25.00) to the general funds of the Foundation.

(*B*) *Corporation:* Corporations or Partnerships who shall make a minimum annual contribution of one hundred dollars ($100.00) to the general funds of the Foundation.

(*C*) *Life:* Those members who shall make contributions to the Endowment Fund of such amounts the income of which at 2½% shall at least equal the minimum contribution of the member's class at the time the contribution is made.

(*D*) *Technical:* Those persons who are faculty members or on the Research Staff of technical schools or on the Research Staff of recognized independent research laboratories or other persons who contribute services as members of the research committees of this Foundation, may be made Technical Members of this Foundation without financial contribution by vote of the Board of Trustees.

Article II

Endowment

Section 1 There shall be created a permanent Endowment Fund in which shall be deposited 5% of all contributions to the Foundation, and such contributions as may be designated by the donors for endowment.

Section 2 The Endowment Fund shall be invested by the Board of Trustees, and the income therefrom only shall be used to carry on the work of the Foundation.

Article III

Affiliation with the American Ceramic Society

Section 1 In order to promote the closest coöperation between the Foundation and the AMERICAN CERAMIC SOCIETY, all members of the Foundation, except Technical Members, shall be tendered to the AMERICAN CERAMIC SOCIETY for membership.

Section 2 All reports and bulletins of the Foundation shall be printed by the AMERICAN CERAMIC SOCIETY without cost to the Foundation.

Section 3 The Foundation will pay to the AMERICAN CERAMIC SOCIETY the sum of $12.50 per year for each member, except Technical Members, of the Foundation to whom the SOCIETY shall issue certificates of membership.

Section 4 Reports of all Technical Committees shall be available to the Program Committee of the Structural Clay Products Division of the AMERICAN CERAMIC SOCIETY for presentation at the meetings of the Division.

Article IV

Nominations and Elections

Section 1 Nominations The Board of Trustees shall select two nominating committees of three members each. One of these committees shall consist of technical members of the committees serving the Foundation; the other shall consist of representatives of the larger contributors to the Foundation. Each of these committees shall nominate three candidates for Trustee.

Section 2 Election (*a*) Not later than thirty days before the annual meeting, the Secretary shall mail to each member a printed ballot containing the names of all six nominees combined as one list and arranged in alphabetical order.

(*b*) Said ballots shall be enclosed in an envelope on which there shall be no mark of identification other than the words "National Brick Manufacturers Research Foundation Ballot." The ballot envelope shall be enclosed in another envelope for mailing, addressed to the Secretary of the Foundation upon the back of which the voter shall endorse his name.

(*c*) The balloting shall close at twelve o'clock noon on the fifth day preceding the opening session of the annual meeting and the actual date shall be printed on the ballot.

(*d*) The envelopes and ballots shall be opened in the presence of three scrutineers, appointed by the President, who will report the results of the election at the annual meeting.

(*e*) The three nominees receiving the largest number of votes shall be elected.

(*f*) In case of a tie vote for one or more of the three places, the names appearing in the tie or ties shall be submitted to the members present at the annual meeting and their decision shall elect. In the case of a tie at the meeting, nominations may be made from the floor and balloting continued until the contested places are filled.

Article V

Committees

Section 1 Executive Committee The Officers of the Foundation shall constitute an Executive Committee which shall manage the affairs of the Foundation under the direction and subject to the approval of the Board of Trustees.

Section 2 Authorization of Committee The Board of Trustees shall create all such committees as are necessary to promote the objects of the Foundation.

Section 3 Committee on Technical Committees The Board of Trustees shall appoint a Committee on Technical Committees, the majority of whose membership shall represent the technical and consuming interests. This committee shall select the personnel, plan the program, and supervise the work and publications of all technical committees, subject to the approval of the Board of Trustees.

Article VI

Amendments

These By-Laws may be amended only in the following manner:

An amendment must be endorsed by the Board of Trustees or by fifteen members and submitted to the President who shall send copies of the proposed amendment to all members of the Foundation at least thirty days before the annual or special meeting at which the amendment is to be voted upon.

For adoption, the proposed amendment must receive the favorable vote of at least two-thirds of the members present at said meeting.

NOTES AND NEWS

INTERNATIONAL PATENT EXPOSITION

An invitation has been extended to the members of this SOCIETY to attend, as guests of the management, the International Patent Exposition, to be held at the Merchandise Mart, Chicago, Illinois, September 14 to 27.

It is said that the world's greatest and most diversified display of new inventions will be on exhibit. There will also be on display the latest products of some of the world's leading manufacturers. Practically every industry will be represented and the Exposition will have an educational and practical importance to all who attend.

AMERICAN REFRACTORIES INSTITUTE FALL MEETING

The Fall Meeting of the American Refractories Institute will be held on Friday, October 9, in the Hotel Cleveland, Cleveland, Ohio.

Papers and discussions of an informal nature will center around the following studies:

(1) Studies conducted at present on dry-pressing of refractories.
(2) Firing of refractories with relation to secondary expansion.
(3) Permeability of refractories at high temperatures to gases.

CALENDAR OF MEETINGS

Organization	Date	Place
American Assn. for the Advancement of Science	December 28, 1931 to January 2, 1932	New Orleans, La.
AMERICAN CERAMIC SOCIETY	February 7–13, 1932	Washington, D. C.
American Gas Assn.	October 12–18	Atlantic City, N. J.
American Society of Mechanical Engineers	September 7–9	Kansas City, Mo.
American Society for Steel Treating	September 21–25	Boston, Mass.
Common Brick Mfrs. of America	February 1–6, 1932	Louisville, Ky.
Electrochemical Society	September 2–5	Salt Lake City, Utah
National Assn. of Manufacturers	October 5–9	New York, N. Y.
National Exposition of Power and Mechanical Engineering	December 5–10	New York, N. Y.
National Glass Distributors Assn.	December 1–3	Pittsburgh, Pa.
National Safety Council	October 12–16	Chicago, Ill.
New Jersey Clay Workers Assn.	October	Trenton, N. J.
Optical Society of America	October 22–24	Rochester, N. Y.
Sand-Lime Brick Assn.	February 3–4, 1932	Washington, D. C.
Scientific Apparatus Makers of America	May, 1932	Wernersville, Pa.
Taylor Society, Inc.	December 2–4	New York, N. Y.
Tile & Mantel Contractors' Assn. of America, Inc.	February 9–12, 1932	Rochester, N. Y.

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Hommel, O., Co.

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B

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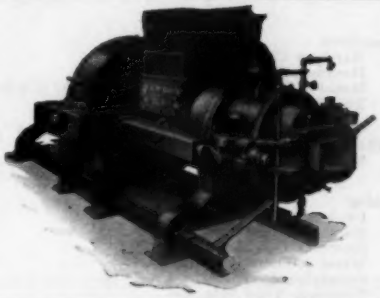

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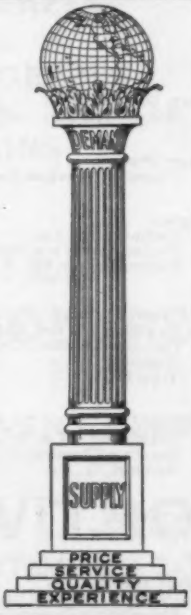

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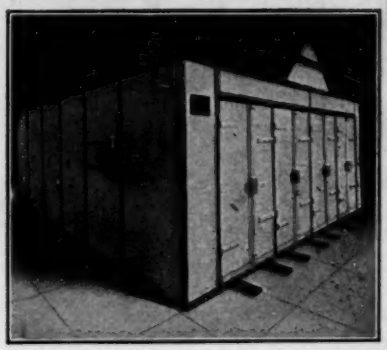

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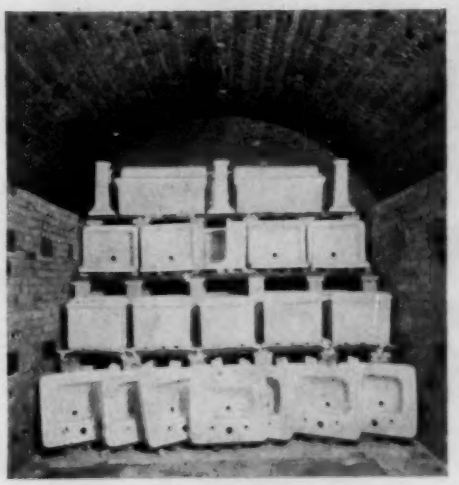

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